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A demonstration and analysis of requirements for maritime navigation planning

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Monterey, California

THESIS

A DEMONSTRATION AND ANALYSIS OF
REQUIREMENTS FOR MARITIME NAVIGATION
PLANNING

by

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March 1998

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13. ABSTRACT *(maximum 200 words)*

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The thesis contains an overview of the current manual navigation planning process used by the U.S. Navy. Alternatives for migrating the current method to an automated process are explored. A requirements analysis is conducted to capture fleet navigator feedback for a prototype automated navigation planning tool.

Conclusions drawn from this study are implemented in the prototype on-line navigation planning tool that has been dubbed "GatorNet." Additionally, a requirements document is developed with the objective of shifting the maritime navigation planning and debriefing paradigm from a manual mindset to an automated one.

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A DEMONSTRATION AND ANALYSIS OF REQUIREMENTS FOR MARITIME NAVIGATION PLANNING

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ABSTRACT

Restricted water transits by U. S. Navy ships require detailed planning by Commanding Officers, Navigators and the entire ship control watch team. The methodical maritime navigation *planning process* currently used has not changed appreciably since World War Two. The process remains a manual one, relying primarily on hard copy data (which is distributed via the U. S. Postal system or other Governmental shipping means) for updates to the navigation picture. The explosion of information sources and technology provides an opportunity to revolutionize the entire maritime navigation planning process.

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I.   INTRODUCTION

A.   CURRENT FLEET NAVIGATION PLANNING AND SHORTFALLS

Restricted water transits by naval ships require detailed planning by Commanding Officers, Navigators and the entire ship control watch team. Standardized navigation planning guidelines have been developed to improve safety and an extensive publication system provides the vast majority of information used in the planning process. Typically this information is dated and does not incorporate organized port visit and harbor transit feedback from the fleet. The planning process has evolved over many years, but the planning tools have changed very little. The explosion of information sources and technology provide an opportunity to revolutionize the entire navigation planning process.

Great strides have been made in providing imagery intelligence through the Joint Deployable Information Sub-System (JDISS). Battle space awareness has been greatly improved using the Joint Maritime Command Information System (JMCIS) by fusing multiple C4I systems into a single tactical display. The Global Command and Control System (GCCS) has evolved and taken the fusion concept of JMCIS one step further, incorporating a UNIX based client server system of standardized relational databases. However, due to the low profile nature of "routine" navigation planning, a lesser effort has been made to use information technology to significantly improve this process.

The shift in focus from blue water to littoral operations has increased near shore navigation operations. Ironically, this seemingly "routine" process provides one of the greatest safety risks during peacetime operations. During wartime operations when mining and near-shore hostile actions require even more precise navigation, there will be an exponential increase in the amount of required navigation planning.

Naval ships safely transit dozens of harbors every day. Navigators plan and brief the transit using a library of hard copy publications designed to provide critical safety information. Occasionally, record messages written by ships that have "recently" made the transit lend valuable insight. Often the Commanding Officer and Navigator have no choice

but to rely heavily on the judgment of a paid pilot (who sometimes speaks broken English) to safely navigate foreign harbors. Quartermasters take visual bearings off radio towers, lights, and water tanks believed to be the proper navigation aid. Visual fixes are compared with Global Positioning System (GPS) measurements as the ship transits the harbor. As the ship approaches the dock, the Commanding Officer gets his first view of the pier, tugs and fittings. After a ship moors, all this information is debriefed in a matter of minutes and rarely, if ever, is any of this valuable information captured and passed on to the next ship that must make the transit. An objective of this thesis is to shift the navigation planning and debriefing paradigm from a manual mindset to an automated one.

Just as with U. S. Navy Food Service, the surface navigation *planning process* has not changed appreciably since World War Two [Ref. 1]. The process remains a manual one, relying primarily on hard copy data (which is distributed via the U. S. Postal system or other Governmental shipping means) for updates to the navigation picture. The explosion of information sources and technology has gone relatively unnoticed as viewed from the eyes of today's U. S. Navy navigation planners. Distributing a relational database on CD-ROM and using the World Wide Web as a vehicle to rapidly provide up-to-date digital navigation planning information to fleet users shows great promise, and is supported by the fleet navigation planners (see Chapter II).

B. FLEET NAVIGATION GUIDANCE AND INITIATIVES

1. Navigation Guidance Provided by the Commanders, Naval Surface Forces, Naval Air Forces Atlantic and Pacific

Standardized navigation planning guidelines have been developed to improve safety. In addition to the extensive publication system, the Commanders, Naval Surface Forces and Naval Air Forces, U. S. Pacific and Atlantic Fleets (CNSL/CNSPINST 3530.4) Instruction provides the vast majority of guidance used in the planning process. Appendix A. is a comprehensive list of all navigation planning publications and products in use in the fleet today.

The Type Commander's navigation guidance primarily focuses on: (a) The flow of navigation information from the Navigation Watch Team to users, (b) Maintaining proficiency in navigation skills, and (c) Emphasizing navigation precision, accuracy and responsibility.

Although there is an acknowledgment in the Type Commander's Instruction of the increasing complexity of ship operations, there is little guidance for applying information technology to help with navigation planning, other than a suggestion to Navigators to use the National Imagery and Mapping Agency (NIMA) Navigation Information Network (NAVINFONET). In short, the focus of the entire instruction is on management of the manual navigation process [Ref. 2].

2. Navigation Sensor System Interface (NAVSSI)

The Navigation Sensor System Interface (NAVSSI, AN/SSN-6) was installed and tested on USS YORKTOWN (CG-48) as a part of the Smart Ship Program. NAVSSI was established to fulfill Chief of Naval Operations (CNO) requirements to use and distribute GPS data as the primary source of navigation data [Ref. 2]. NAVSSI contains the following functionality:

- Provides an accurate and automated distribution of navigation data to the shipboard users.
- Allows the ship's Navigator and bridge crew to perform mission planning, underway voyage progress tracking, and formation steaming functions using Government Off-the Shelf (GOTS) software.
- Distributes real-time, best available navigation data.
- Provides data for use by strike warfare systems for GPS initialization.
- Places control of navigation selection and distribution in the hands of the navigation team.
- Provides the navigation team with a workstation for Battle Group navigation planning and monitoring.

- Provides a system to support safe navigation using digital nautical charts and chart tools, to meet Electronic Chart Distribution Information System (ECDIS) functionality. NAVSSI is beginning to be installed aboard fleet ships, and also has been introduced into navigation training at the Fleet Training Centers Atlantic and Pacific.

3.   **NAVINFONET, NAVCEN, and MARILOG**

There are several U. S. Government and commercial tools and World Wide Web Sites that have been created to aid in Navigation Planning. NIMA maintains an American Standard Code for Information Interchange (ASCII) based bulletin board system called the NavInfoNet, or Navigation Information Network, to help provide timely navigation safety information to military and civilian mariners. By dialing up a 9600 baud phone line at NIMA, a user can obtain information such as Chart Corrections, Broadcast Warnings, Maritime Administration Advisories, List of Lights, Anti-shipping activity messages, and U. S. Coast Guard Light Lists. Although there is no charge for the use of the system, there are long-distance telephone charges involved, and this can be cost-prohibitive for the ship at sea using the expensive International Maritime Satellite (INMARSAT) single channel telephone system. Some ships have reported that they are not allotted enough phone lines to permit use of a single line for NavInfoNet. NIMA recognizes the shortfalls of this ASCII based system, and is currently upgrading it into a graphics based World Wide Web site, scheduled for implementation in October 1998 [Ref. 3].

There are other sources of navigation information that are available now on the World Wide Web, such as the Coast Guard's Navigation Center web site called NAVCEN [Ref. 4]. Some of the useful navigation information available at this site includes Local Notices to Mariners and navigation communications advisories for LORAN-C (Long-Range Navigation) and GPS. In addition, there are numerous other non-government navigation and marine safety web sites, such as the Institute of Navigation [Ref. 5] and MARILOG [Ref. 6] sites, which contain information such as safety advisories and advertisements on commercial navigation products.

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4.   The Computerized American Practical Navigator (Cap'n)

The Computerized American Practical Navigator (Cap'n) is a commercial software navigation tool widely used on Naval Ships. Its functionality is broad, and navigators can use it to manage daily navigation chores including voyage planning and navigating with computer display electronic charts via GPS or celestial inputs [Ref. 7]. Numerous other useful functions include tide and current predictions, set and drift calculation and automatic dead reckoning. Also, several large databases can be accessed through the tool including Aids to Navigation, NIMA and NOAA charts, undersea features and ports. Nautical Technologies, Ltd. distributed a demonstration version of this commercial software package to the fleet in 1994, and several hundred U.S. fleet ships have reported that they are using the program (see Chapter II).

Although the usefulness of the Cap'n program is obvious, it has yet to be officially sanctioned and distributed by the U. S. Navy. In fact, NAVSSI is the Navy's answer for electronic charting. One weakness of the Cap'n system is that it was designed to operate in a stand-alone mode, and not to be interfaced with the World Wide Web. Although it is a powerful tool and it continues to be improved, it is still not a single source system tailored for all of the Navy's navigation planning needs.

C.   RELEVANT FLEET C4I INITIATIVES

There are numerous Command, Control, Computer, Communication and Intelligence (C4I) initiatives underway by several federal agencies that to some extent or another are merging navigation with information technology. Many of these initiatives focus on using digitized nautical charts, improving navigation accuracy through use of Differential GPS (DGPS) or the Ring Laser Gyro Navigator (RLGN) inertial navigation system, and integrating these technologies into an information suite on the ship's bridge.

Some of the leading Department of Defense C4I initiatives include:

1.   **GCCS**

The Global Command and Control System (GCCS) is a "system of systems" which has replaced the Worldwide Military Command and Control System (WWMCCS) as the U. S. Joint command and control system. There are several GCCS applications that have tremendous relevance to the management of the surface navigation problem. Logistical information contained in key port databases, for example, permits planners to determine well in advance if a particular port can support a ship visit. These GCCS applications include:

a)   *Airfields Databases via JOPES and DAFIF*

A Joint Operation Planning and Execution System (JOPES) application on airfields exists and is interfaced with GCCS. However, it is extremely difficult for a fleet user to access this database, as the application is only licensed by the Defense Information Systems Agency (DISA, the GCCS program manager) to ten Commander in Chief (CINC) level commands. NIMA also maintains the Digital Aeronautical Flight Information File (DAFIF). This database contains airport, runway, navigation aid, enroute and terminal data [19].

b)   *Ports Database via GSORTS*

A Ports Database is available via the GCCS Status of Operational Readiness and Training Systems (GSORTS), and contains some useful information on potential ports of call. This information is similar to that available in the government's Publication 150, the World Ports Index.

c)   *Overlay management via COMPASS Middleware*

The Common Operational Modeling, Planning and Simulation Strategy (COMPASS) is an application of services interfaced with GCCS. This system permits

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staff planners to model and simulate plans in a real-time, collaborative manner. Scenarios ranging from chemical warfare to amphibious assault can be tested to build insight into exercises and actual combat operations [Ref. 8]. The system was designed to use real-world data to help planners evaluate the key decisions of an operation. COMPASS also contains some functionality that is useful for navigation planning, such as chart and map overlay capabilities.

d) SIPRNET and NIPRNET

The Secret Internet Protocol Router Network (SIPRNET) is the secret-level packet data portion of the Defense Information Systems Network. The backbone of SIPRNET is a DOD Wide Area Network (WAN) composed of an autonomous network of new hardware and software. SIPRNET is integrated with GCCS and allows users to transmit and receive classified data up to the Secret/Noforn level from a variety of subsystems and applications [Ref. 9:pp. 7-78]. Concurrently, the unclassified but sensitive Internet Protocol Router Network (NIPRNET) uses commercial protocols to transport unclassified data over the Defense Information Systems Network. Both the SIPRNET and NIPRNET have been installed and are in worldwide use. These trusted conduits provide more than adequate potential for growth, and might include a prototype navigation planning Web site.

2. Lessons Learned Database

The U. S. Navy maintains an extensive database of ship, submarine, and squadron lessons learned via the Navy Lessons Learned DataBase (NLLDB). Fleet personnel created this library of corporate knowledge with message input using the Navy Instructional Input Program (NIIP) [Ref. 10]. The entire database is distributed quarterly by the Director, Navy Tactical Support Activity, in the form of CD-ROMs. This digitized information is a part of the Navy Tactical Information Compendium (NTIC) series "A." A more thorough discussion of this system is contained in Chapter II, Section B.

3. Internet to Sea (SEANET) Program

The SeaNet Project is a collaborative effort to bring the Internet to all fleet ships. The program was originated as an academic study at the Naval Postgraduate School in Monterey, California. There are many dimensions to the project, including global connectivity via future Low Earth Orbit satellite networks. The basic concept of widespread Internet access to ships at sea with healthy bandwidth resources is a cornerstone of the project [Ref. 11]. The concept of using commercially available communications and protocols can also be applied to a prototype navigation Web Site.

4. Gobal Broadcast Service

The Global Broadcast Service (GBS) is a DOD application of commercially developed technology. The service consists of a network of high-powered satellites and small receive terminals. When the service is established in the near future, an exponential increase over current Satellite Communication (SATCOM) capability and bandwidth will result, due to the use of smaller antennas and higher data rates [Ref. 12]. In short, this initiative is undergoing initial operational testing, and appears to be a promising means of increasing available bandwidth to fleet users.

5. Information Technology for the 21st Century (IT-21)

Information Technology for the 21st Century (IT-21) is a Fleet Commander in Chief initiative to push all administrative and tactical computing business to desktop personal computers. The following excerpts from the Commander In Chief, U. S. Pacific Fleet's vision, summarize the concept:

> A shift from platform centric warfare to network centric warfare; ....principal elements of IT-21 are afloat LANs and ashore LAN/WANs populated by 'state-of-the-shelf' personal computers which will integrate tactical and tactical support applications with connections to enhanced satellite systems and ashore networks. Furthermore, IT-21 is a philosophical C4ISR warfighting process transformation away from expensive, single-function workstations to affordable, highly capable personal computers.

In short, the IT-21 plan envisions that all naval computer business, both tactical and non-tactical, will be driven to a single, networked, desktop computer [Ref. 13]. This movement has generated widespread support throughout the Navy, including the support of the Department of the Navy Chief Information Officer (DON CIO). One of the largest benefits this movement will bring to fleet navigators is a significant increase in the numbers of networked microcomputers available for both World Wide Web access and navigation planning.

D.   A NEW TARGET ARCHITECTURE

Key to a new target navigation planning architecture's success is accessibility by the navigation watch team and user friendliness. If the entire planning concept and feedback process becomes too difficult, the system will fail. A working solution to the manual navigation-planning problem is proposed in the form of a prototype Web Site. The tool has been developed and a Web site was used so that the fleet can immediately appreciate it. The current planning process has been thoroughly researched and detailed requirements from the fleet have been incorporated into GatorNet, the Navigator's Planning Network.

E.   SUMMARY OF REMAINING CHAPTERS

Chapter II describes the methodology used to design and disseminate a navigation survey to the fleet. The chapter presents data collected and analyzes user requirements and how they relate to ongoing initiatives. Alternative hardware platforms and technologies for a navigation planning system are explored in Chapter III. A discussion of automating traditionally manual navigation tasks is included. An overview of the GatorNet rapid prototype, a World Wide Web based navigation planning tool, is presented in Chapter IV. Functionality of the tool is discussed and design considerations are included. Software tools used to create the graphical user interface are explained in detail. A discussion of issues in implementing and integrating the prototype into the fleet is

presented in Chapter V. Finally, recommendations for further research and lessons learned are presented in Chapter VI.

II. REQUIREMENTS ANALYSIS

A. FLEET SURVEY DESIGN

1. Methodology

To better understand the fleet's requirements for navigation planning, the survey in Appendix B was distributed throughout the fleet. Due to the widely dispersed population, a survey was deemed the only feasible tool for data collection. It was used as an exploratory study to gauge overall opinion before giving the working prototype any specific direction. The total population of ships and staffs was known to be less than five hundred. Some of the groups that would be analyzed had a smaller population (i.e. 12 CV/CVNs, 27 CG/CGNs, 24 mine warfare ships). Anticipating a return rate less than 50%, it was necessary to survey the entire population to maintain statistical significance when looking at those smaller. groups. Since the survey was also meant to obtain new ideas, a population-wide survey was appropriate.

In order to increase the return rate, a cover letter was included and the surveys were sent directly to the Commanding Officer. The desired respondent was the ship's Navigator or staff's Navigation Plans Officer. It was requested that commands reproduce copies locally to obtain opinions of the Operations Officer, leading enlisted Quartermasters (QMs), and leading enlisted Operations Specialists (OSs). To encourage feedback yet allow group comparison, the survey maintained anonymity and collected the following demographics:

- Rank

- Title/Job Position

- Time in Billet

- Command

- Command Status (ashore, deployment, work-ups, etc.)

To encourage further feedback, the survey was kept to the front and back of a single sheet of paper. Surveys are plentiful within the Navy and it was deemed important not to impose upon the fleet. The cover letter stated it should take no longer than ten minutes to complete the survey.

Since many of the requirements to host an on-line system are not in the fleet, it was important to place a disclaimer at the top of the survey. The following note was included: *Although you may not currently have access to the World Wide Web, please assume you have it or will have it in the near future when responding to these questions.* Valid connectivity concerns and availability of computer hardware surfaced throughout the responses despite our effort.

2. Survey Formulation

A cross-section of open and close-ended questions was used on the survey. The open-ended questions were designed to answer the following questions:

- How much did the fleet know about ongoing initiatives? What did they think of these initiatives? (Question 2)

- What did the fleet think of the existing navigation planning system? Would they be willing to change from the existing publication system to a computer-based system? (Question 3)

- What type of Navigation Lessons Learned were commands maintaining and how much importance did they place in lessons learned? (Question 4)

- What computer hardware did users feel comfortable with? (Question 5)

- What type of navigation planning information had been sought in the past that was important to include in a single data repository and possibly the prototype? (Question 7, Question 10, Question 14)

- How could the existing navigation feedback systems be improved? (Question 13)

The closed-ended questions were designed to achieve the following:

- Where should we focus our prototype effort? (Question 6)

- How useful is the existing Navy Tactical Information Compendium (NTIC) Lessons Learned System for Navigation planning? (Question 8)

- How much time is spent correcting and maintaining navigation sources of information? (Question 9)

- Which fleet and commercial systems are being used for navigation planning? (Question 11)

In Question 6 a scale was provided to the respondents ranging from one (*Not Important*) to five (*Essential*). The scale's intervals were assumed equal to allow quantitative analysis.

3.   Data Grouping

Since some ships sent more than one response (as requested), it was necessary to separate the data to keep multiple responses from influencing command specific questions. The entire set of data was initially grouped into two categories: *all responses* and *one response per command*. The *all responses* category was used to compare and contrast groups such as enlisted versus officer, time in position, or command types (i.e. ship versus sub responses). A junior quartermaster on a ship who took the time to fill out the survey had equal weighting with an executive officer of the same ship. The *one response per command* category was used to determine the number of ships using commercial products, the hours spent maintaining publications, or the type of lessons learned being maintained. The response that was chosen in the case of multiple responses per unit was the navigator's or the job title of a respondent that came closest to that position.

We formed a hypothesis that we might see a distinction in results among senior and junior personnel, Navigation and Operation departments, and platform size and types. Therefore, demographic data was collected to group results by job title, time in billet, rank, and ship type. When presenting the data, the groups in Table 2-1 are used.

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Table 2-1 Group Compositions

Group	Ship Classes/Explanation
Large Decks	CVN, CV, LPH, LHD, LHA, LCC, MCS
Small Boys	CG,DD, DDG, PC, LPD, LSD, LST, MCM, MHC, PC
Crudes	CG, DD, DDG, FFG
Amphibious	LSD, LPD, LHD, LPH, LHA, LCC
Auxiliary	AGF, AGSS, ARS
Logistics	AE, AO, AOE, T-AFS, T-AO
Mine Warfare	MCM, MCS, MHC
Submarines	SSN, SSBN
Junior Officers	Ensign up to and including Lieutenant Commander

B.   PRESENTATION OF COLLECTED DATA

1.   Respondent Demographics

Surveys were sent to 396 separate commands.   159 of the 396 commands responded for a return-rate of 40.2%. Due to multiple responses by several commands, 238 total responses were received. Table 2-2 shows ship respondents by broad categories and percentages of their respective population. Table 2-3 shows similar data for staff responses.   A consistent survey response rate of approximately 40% was achieved across all categories.

Table 2-2 Ship Responses

Category	Responses	Population	Percentage
Carriers (CV/CVN)	6	12	50.0
Cruisers (CG/CGN)	12	27	44.4
Destroyers(DD/DDG)	21	56	37.5
Frigates (FFG)	16	42	38.1
Amphibious	13	42	31.0

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Submarines	30	86	34.9
Mine Warfare	10	24	41.7
Patrol Craft (PC)	5	13	38.5
Logistics	11	18	61.1
Auxiliary	7	11	63.6
Total	131	331	39.6

As was expected, the majority of responses came from junior officers (O-1 through O-4) holding the job of Navigator between 12-36 months. Demographic data on individual respondents is shown in Figures 2-1 and 2-2.

Table 2-3 Staff Responses

Category	Responses	Population	Percentage
CARGRU	4	8	50.0
CRUDESGRU	2	6	33.3
SUBGRU	5	5	100
PHIBGRU	0	3	0
DESRON	7	17	42.2
SUBRON	3	10	30
PHIBRON	4	9	44.4
Total	27	63	42.9

Appendix C contains summary information in numerical format. It is important to note that in Figure C-1 of Appendix C, there is an overlap between the job title of Assistant Navigator (ANAV), Leading Petty Officer (LPO) and Leading Chief Petty Officer (LCPO). The numbers in the figure represent the titles as received on the survey, but in fact many LPO's and most of the LCPO's are also the ANAV.
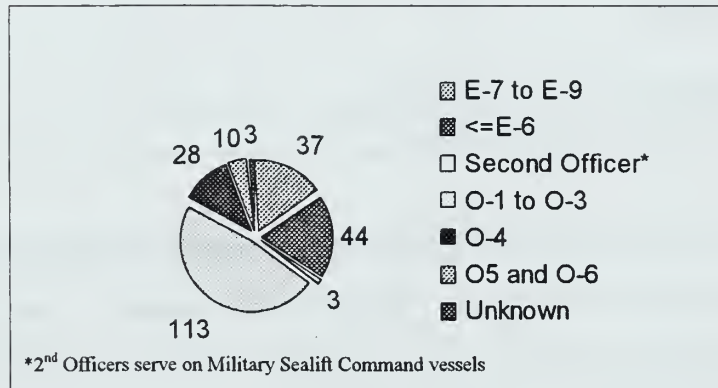
Figure 2-1 Response by Rank
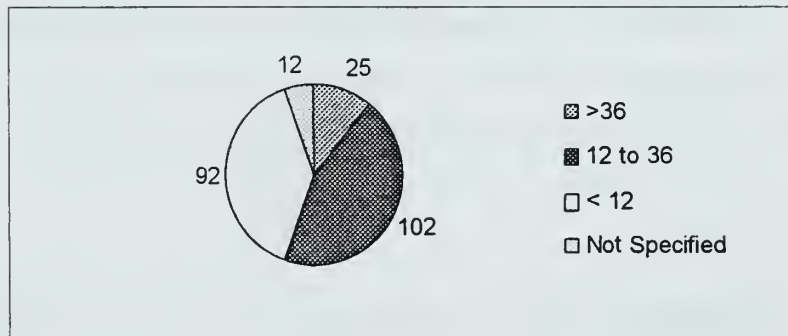
Figure 2-2 Response by Months in Billet

Although comparing and contrasting data from the various groups was not a primary concern, having the data grouped allowed us to test several hypotheses:

- Were enlisted and officer opinions significantly different?

- Did time in a job change opinions?

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- How did navigator and quartermaster responses compare to operations related job positions?

- Did ship type have an impact on results received?

Each of these sub-groups was large enough to provide statistically significant information.

2. Statistical Validity

To allow valid inference about a population based on a sample, it is important that the principle of randomness be embodied in the sample selection procedure [Ref. 14:p. 270]. With our sample containing only the returned results there is some possible influence on the randomness of the sample. We assumed the US Postal Service was 100% reliable (in fact one response returned with an open envelope and no survey inside). It is presumed that commands that did not return the results could not find the time, lost the survey, or simply chose not to respond. For our purposes, we will assume one of the first two instances and therefore this principle of randomness is somewhat intact. Since the observation values are integers between one and five for Question 6, the population distribution is certainly not normal. However, thanks to the Central Limit Theorem whatever the common distribution of a set of independent random variables, provided that their variance is finite, the sum or average of a moderately large number of them will be a random variable with a distribution close to the normal [Ref 14:p. 207].

To determine whether the samples statistically portray their respective population, several confidence intervals were computed for groups of varying sample sizes. Question 6 of the survey provided guidance toward the features to be included in the prototype. The authors felt it would be useful to include pictures of aids to navigation so that prior to harbor transits, quartermasters could get a mental image of the aid. When shooting visual bearings, it is often difficult to correlate charted aids that have never been seen with actual navigation aids—especially if the surroundings have been built up due to construction or if more than one similar aid exists (i.e. multiple radio towers). A picture can eliminate any confusion and like the cliché it is worth a thousand words. Appendix D contains the

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calculations for the statistics contained in Table 2-3 using the *Picture* responses on the survey.

Table 2-4 Confidence Intervals

Group	Sample Size (n)	Sample Mean / Std Dev (s$_x$)	Confidence Interval	Computed Population Mean
Amphibious	13	4.29 / .85	95%	3.78 < μ < 4.80
Amphibious	13		90%	3.87 < μ <4.71
Amphibious	13		80%	3.97 < μ < 4.61
Navigators	103	4.19 / .71	99%	4.01 < μ < 4.37
Navigators	103		95%	4.05 < μ < 4.33
Navigators	103		90%	4.08 < μ < 4.32
All Respondents	238	4.10 / .94	99%	3.94 < μ < 4.26
All Respondents	238		95%	3.98 < μ < 4.22
All Respondents	238		90%	4.00 < μ < 4.20

Observing the confidence intervals for the population means, even the smallest sample group of amphibious respondents provides a tight enough interval for our purposes. By relaxing the confidence to 80%, one can hypothesize that the entire population of amphibious ships (42) find having pictures included in the prototype important (4 on the scale of 1 – 5).

The information obtained from the surveys follows by question number. In many of the tables, the two groups of responses are compared: *All Respondents* and *One Response per Command*. This is done to compare and contrast the Navigator/Navigation Plans Officer responses with all returned samples.

3.   Systems Hardware Results

a)   *Question 3: Type of Planning System Desired*

The overwhelming majority (68%) of respondents stated they would prefer an online system compared to the current publication system (Table 2-5). "On-line" was not defined, but most respondents interpreted this as computerized and not necessarily connected to the Internet or a network. Many stated the "on-line" system would save space—notably Patrol Craft (PC), Mine Countermeasure Ships (MCM), and Submarines. On the other hand, these same individuals expressed concern for the availability of

computer assets. Typically, smaller ships have far less computer assets and less telecommunications connectivity capability. Many felt an online system could reduce their workload on correcting publications and charts. The 35 respondents who stated they wanted both an online and hard copy publication capability for the most part stated they did not trust an "online" source to have the reliability necessary for a navigation planning system. The 23 respondents who stated they wanted to maintain the current publication system primarily did not see the cost benefit of introducing a new system. Both the reliability and cost issues are valid and will be addressed in later chapters. There was very little difference between the two groups of information. The results are listed in the following table.

Table 2-5 Question 3 Navigation Planning System

Answer	One Result/Command	Percentage	All Respondents	Percentage
Online	112	69	160	68
Both	23	14	35	15
Publication	19	12	23	10
Neither	3	2	5	2
No Response	5	. 3	13	5

b)   Question 5: Configuration for a Consolidated location or "Library" of electronic Navigation Information

Question 5 was intended to gauge the willingness of individuals to embrace technology. It was also written in an intentionally ambiguous way using "configuration" so as not to influence the results toward a certain technology and to see what new ideas could be generated. It may have been too ambiguous since many respondents stated they did not understand what was meant by "configuration". Many declined to answer the question (33% of all responses). Those that did answer overwhelmingly felt CD-ROM would be the medium of choice (Table 2-6). Not only are CD-ROMs a very logical choice

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for a "library" of electronic information, but the National Imagery and Mapping Agency (NIMA) is currently digitizing publications and distributing them on CD-ROM. Only a handful of publications (Sailing Directions, Port Directory etc.) have actually been introduced to the fleet, but this may have influenced the survey responses. This digitization is a start in the right direction, but is primarily aimed at paperwork reduction. An interactive program where all sources of information including graphics can be queried and searched would be more ideal.

Ideas submitted for the *Other* category included updated disk distributed quarterly; user friendly; Navigation Sensor System Interface (NAVSSI) compatible; and JMCIS resident.

Table 2-6 Question 5 Configuration

Question 5 Results	One Result/Command	Percentage	All Respondents	Percentage
CD-ROM	58	35	82	34
WWW	10	6	16	7
WWW/CD-ROM	5	3	7	3
Online	3	2	4	2
Other	42	25	51	21
Blank Response	47	28	78	33

4.   Lessons Learned Results

a)   Question 4: Lessons Learned "library" Currently Maintained

This question was intended to measure not only what commands maintained, but also gain insight on the value that they placed on lessons learned. The range of answers was quite broad from "none" to "binders containing information on each harbor transit." The responses (Table 2-7) were grouped into the following categories:

None, Safety/Mishaps, Port Visits, Lessons Learned, Nav Briefs, and Other. *None* was only tallied if the command actually stated "none". The rather broad category of *Lessons Learned* was marked if the command was not specific in their response but made any mention of maintaining some aspect of lessons such as message traffic. Had we asked them to mark boxes of the categories, more accurate data would have been collected. Unfortunately, by giving the categories to the respondents, we felt we might influence their answer—no command wants to admit they don't maintain a file on safety messages, port visits or navigation details. With an open-ended question, the tradeoff was less accurate quantitative data, but there was less chance of simply "checking a box."

Types of lessons learned categorized as *Other* include: Collision briefs, Port Directory, Historical, Check rides, NTIC etc. If there is any conclusion to be drawn from question 4, it is that surprisingly few commands maintain a serious navigation lessons learned library. The fact that fully 25% stated *None* or did not respond and that no single category was above 38% shows considerable room for improvement. Although the formulation of the question may have reduced the results, many commands are seemingly reinventing the wheel.

Table 2-7 Question 4 Lessons Learned Maintained

Question 4	Number Mentioned	Percent of Commands
None	20	12
Safety/Mishap	40	24
Port Visit	60	36
Lessons Learned	63	38
Navigation Briefs	14	8
Other	16	11
No Response	21	13

b) *Question 8: Navy Tactical Information Compendium (NTIC) System*

The NTIC CD-ROMs are distributed quarterly to the fleet. They contain the Navy's Lessons Learned System (NLLS) which was established in 1991. Before that, no formalized methodology for collecting and distributing lessons learned existed within the fleet. The initial focus was limited exclusively to operational issues that had proposed workarounds. This policy excluded substantial information in other areas during fleet operations and exercises. For the purpose of this system, a lesson learned is information expressly and specifically contributing to the value of the Navy's established body of knowledge [Ref 10]. To qualify as a lesson learned, an item must reflect "value added" to existing policy, organization, training, education, equipment, tactics, techniques or doctrine by identifying problems areas. The NLLS provides a responsive method for identifying deficiencies and initiating corrective actions. However, this approach reduces lesson learned information that could be derived from policies or doctrine that work and are not "problems". Somebody preparing for a similar exercise or operation could gain confidence or insight into how successful policies or doctrine worked. In an effort to minimize the database and focus on correctable issues, the existing system excludes positive feedback. The secondary objective is to minimize the system's cost by using a text-based database system to collate, evaluate and disseminate Navy-specific lessons learned. The system allows standard search queries for phrases or words. It is compatible with the Joint Universal Lessons Learned System [Ref. 15].

Although it is desired that all lessons learned gravitate toward this single system, the reality is that many navigation lessons learned in the fleet take the format of after action messages or inputs to the Port Directory Guide. Searching the NLLS reveals some navigation information, but far from a comprehensive database. The purpose of our asking question 8 was to test the fleet's familiarity with the system as well as see if anybody was using it for exercises, transits, port visits or amphibious operations. The survey results indicate the system is a failure with respect to navigation. As shown in Table 2-8, fully 47% of the respondents have never even used the system and 36% more

use it less than once per month. Those using the system do not appear to use it for purely navigation related matters. Our survey respondents are the individuals who are supposed to submit the lessons learned. If they are not using the system to obtain lessons learned, this may indicate why so few navigation-related lessons learned exist within the system.

Table 2-8 Navy Lessons Learned System

Frequency NTIC Use	Responses	Percent	Type of NTIC Use	Responses	Percent
Never Used System	112	47	Exercise	38	30
Seldom (< 1/Month)	85	36	Transit	4	3
Regularly (> 1/Week)	26	11	Port Visit	12	10
No Responses	14	6	Amphibious	2	2
			Exercise & Transit	7	6
			Transit & Port Visit	14	11
			Exercise & Port Visit	14	11
			Other Combinations	13	10
			Other Uses	6	5
			No Response	15	12

c) *Question 13: Capturing Fleet Feedback and Navigation Lessons Learned*

This question was intended to generate ideas on how to best improve the existing lessons learned process. The Fleet Intel Collection Manual (FICM)/ONI requires a Port Visit Report to be completed by select ships after foreign port visits [Ref. 16]. This report contains useful logistic and navigation information, but the enforcement of the report and redistribution of information to the fleet navigator is lacking [Ref. 17]. The current methods of after action messages, Port Directory inputs, FICM reports, and the NLLS are designed to provide only qualitative information. No system is in place to

actually collect data and generate quantitative results. For example, a simple formatted survey could be constructed that required navigators to rank the pilots, tugs, navigation aids, currents, pier fittings or other aspects of the navigation detail. Survey questions could also collect qualitative commentary. A ship preparing for a foreign harbor transit could query the database by ship class, timeframe, or response type. This would provide considerably more information in preparing for the transit, and allow greater insight into what to expect. Since we envisioned building such a port survey into the prototype, we didn't want to influence the respondents and used an open-ended question to generate new ideas.

The responses were quite varied and ranged from "can't be done" to "establish a required format." Many brought up interesting points like how do you validate the data or prevent misinformation. Some saw this as an added burden and felt the system was already in place. The consensus felt a required, formatted survey would work that was sent to a central database. They mentioned surveys could be uploaded at the earliest opportunity via e-mail or via the WWW. A creative response mentioned a web site could list critical information that was lacking and needed to populate the database. It was difficult to quantify this open-ended question. In general, the positive responses far outweighed the negative, which indicated people saw a need for an improved system. The results of question 13 are in Appendix E.

5.   **Prototype Information Results**

a)   *Question 6: Importance of Navigation Information Sources*

To aid in the design of the prototype, question 6 gave the respondents a chance to tell us how important different types of information would be if accessible in a single location (system). It gave us a chance to test what we felt was important to include against the fleet's requirements. Since the prototype would not contain all information, it also helped us focus our efforts on what the fleet found most important. Using the demographic data, this question provided a potential wealth of statistical and grouping

analysis. When comparing groups of responses throughout question 6, what actually stands out is how little difference truly exists.

Due to the large number of graphs obtained from this question, they have been grouped together in Appendix F. Graphs F-1 and F-2 provide a visual depiction of how respondents answered on the scale of 1 (Not Important) to 5 (Very Important). Graph F-1 is for all respondents and F-2 is the One Response/Command group. There is very little difference between the two graphs. The same data grouped by percentages is included in graphs F-3 and F-4. What is obvious from these four graphs is the relative importance placed on the categories of information:

- Port, Meteorological and Safety data were all ranked *Very Important* by over 50% of the respondents. Over 90% of the respondents ranked Port and Meteorological data *Important* or *Very Important*.

- Over 85% of the respondents ranked Pictures, Lessons Learned, and Safety as *Important* or *Very Important*.

- Digital Pubs and Digital Charts received very similar support with 79% ranking them *Important* or *Very Important*.

- Exercise and Imagery data followed with decreasing support and more dispersed answers.

- Amphibious data received the least support but this is likely due to the small number of ships that directly participate in these operations.

Each of the remaining graphs in Appendix F compare demographic groups and provides the average response, the standard deviation, and the mode. These three statistics are provided to allow full interpretation of the data. To begin the group analysis, Graph F-5 was constructed to compare every sub-group and uncover significant anomalies. The lines between data points are insignificant, but leaving them in the graphs aids in seeing trends and finding specific data points within tight groups of data.

When observing the data, several questions can be asked. How far out must a sample group lie to be significant? More to the point, does it matter whether large deck ships think safety is .5 higher on the scale than the remainder of the groups? The

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deck ships think safety is .5 higher on the scale than the remainder of the groups? The statistical formulas exist to test for the difference between population means, but the results did not prove tremendously useful. What was more interesting and insightful was to construct several graphs comparing logical groups, observe the data trends, and interpret the suggested results. The Navy is an organization full of communities rich in heritage. The greatest value of breaking the data into groups may likely be the ability of the reader to see how "their community" answered.

Graph F-5 illustrates the strong support by all groups for the various types of information. As expected, amphibious ships ranked the amphibious data between *Important* and *Very Important*. Submariners who rarely operate in that regime gave that category the lowest mark. Graph F-6 shows Ship versus Sub versus Staff responses. The data suggests staffs find digital pubs, imagery, amphibious and exercise data more important than submariners do with ships falling in-between. This correlates with each of these groups' special needs to conduct their primary missions. All three groups were in very close agreement with the importance of pictures, lessons learned, safety and port data. Graph F-7 further broke down the commands by specifying ship types. In addition to the amphibious data as mentioned before, large deck ships stand out on the importance of safety data. Graph F-8 compares big deck ships with small boys. Many small boys had mentioned the space saving convenience of digitizing pubs in the open-ended questions. The data contained in this graph supports this notion.

The next series of groups compared job titles and ranks. Graph F-9 compares Operations Officers with Navigators. Very few differences exist except to note that Navigators find pictures more important (they of course would primarily be the ones using them) and Operations Officers find amphibious and exercise data more important. Graph F-10 tried to show difference based on time within the job. Nothing particularly significant stood out. Graph F-11 broke the results out by rank of the respondent. The data suggests the young quartermaster out shooting navigation aids find pictures more important than the senior enlisted who has done it "the hard way" throughout his career.

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Similarly, the E-6 and below who must maintain and retrieve a publication from the chart room found digital pubs more important than the Lieutenant Commander and above who may on occasion read the publication. There was a perplexing and sizable spread (.7) with respect to exercise data between E-6 and below ranking it the highest and O-4 and above the lowest. Once again, the value added by grouping the data and comparing may be nothing more than an appreciation for sub-cultures within the Navy. The significant result to take away from question 6 is the fact that the vast majority of individuals place a high level of importance in almost every one of these categories.

b) *Question 7, 10 & 14: Additional Data Sources Desired, Missing Information Obtained from Other Commands, and Comments and Suggestions*

These three questions were open-ended with the intent of obtaining the overlooked or original idea. Many terrific ideas were obtained and Appendix E contains the vast majority of them. The following short list provides a sample of suggestions to include in a planning system:

- Harbor regulations, Bridge to Bridge channel information, Vessel Traffic Scheme manuals

- Quality of Navigation aids used for head bearings and drop bearings when anchoring

- Sanitized Navigation Mishap Reports and Lessons Learned for Training Evolutions

- Schedules Database for CINCLANTFLT or CINCPACFLT

- Oil Rigs, Fishing Areas and Merchant Shipping Lanes

- Amphibious Beach Surveys

- Feedback section for inaccuracies found in existing publications

- Foreign Charts and Publications (such as British Admiralty Charts)

- Husbanding Agent e-mail addresses and phone numbers

6. Existing Navigation Tools

a)   Question 11: Current Systems in Use for Navigation Planning

There are many systems that can be used for voyage planning, computing sunrise/sunset or plotting tides and currents. Most of them are commercial products that must be purchased out of the ship's budget. This question was included to gain insight into what is already being used in the fleet. The results were quite interesting. 107 Commands marked that they used a commercial product. Sixty or 56% of the commands are using a commercial software program called the Cap'n which contains many features for voyage planning, electronic charting, chart inventory, celestial computations and tides and currents (Chapter I). It is designed to operate on a desktop PC. Having used an earlier version of the Cap'n as a Navigator for voyage planning, it was easy to understand the timesaving that could be achieved. Purchasing electronic charting capabilities can be prohibitively expensive for individual ships and we did not measure how many commands have actually purchased this feature. The Navy's current development of NAVSSI, which is slowly being installed on ships and recently introduced in the Navigation Schoolhouses in July 1997 [Ref 18], will provide many similar features of the Cap'n product. A comparison of the two products would make for an interesting study of Commercial Off-the-Shelf (COTS) software technology.

There was no other commercial product mentioned with such frequency. Stella is a celestial computation software that is freely distributed to ships (may not have been considered a commercial product by many respondents) and received the next highest response rate with 13. Other products that received mention include: Navtrek (1), Micronautics (1), Tru-Chart (1), Sperry ECDIS (3), Chart Nav (1), Waypoint for Windows (2), and various tides and current programs.

Access to GCCS, JDISS, and WWW systems onboard ship is currently limited to the upper level staffs and large deck platforms. It is not surprising that these systems were not marked more frequently. The results are contained in Table 2-9.

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Table 2- 9 Systems Used for Navigation Planning

System	GCCS	WWW	JDISS	Commercial
Used	9	25	14	107
No Response	153	138	148	55

b) **Question 9: Time Spent Maintaining and Correcting Hardcopy Materials**

To ensure safety of navigation, publications and charts require continuous maintenance as weekly changes are announced (Notice to Mariners and Local Notice to Mariners). A set of charts and publications used regularly must always be kept up to date [Ref. 18]. Charts and publications that are maintained in inventory for an overseas deployment or that are rarely used will have a Chart Card associated with them. The card will be "charged" or annotated if an outstanding correction must be made before use. Much of the quartermaster's time is spent conducting this necessary maintenance. This extremely labor intensive process requires meticulous attention and can be susceptible to human error. Until a system can be devised that provides standardized, automatic electronic corrections little will change. A conceptual system might have publications on CD-ROM with a "Correction Database" cross-checked before the information is presented. This "Correction Database" could be in the form of a 3-½ inch diskette mailed weekly or a download from an online update.

This question was included for completeness and as an opportunity to gather fleet wide statistics. If the process could be automated, significant man-hours could be saved. Another advantage would be reduction of errors. The standard deviations

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of the results in Table 2-10 were extremely high. This can be partially attributed to the variety of operating environments and partially to the difficulty in Navigators accurately estimating or averaging these tasks. This data is not typically maintained or tracked by Navigators, although mapping this process may uncover some interesting results.

Table 2-10 Weekly Maintenance Hours

Question 9	Hydro and NOTAM Files	Nav Publications	Nav Charts	Other
Hours	4.4	7.2	12.1	10.9
Standard Deviation	4.4	7.1	14.2	8.4

C.   REQUIREMENTS VERSUS ONGOING INITIATIVES

There are several initiatives that are underway to improve navigation within the fleet. The most notable is Navigation Sensor System Interface (NAVSSI), which provides electronic charting tools, voyage planning, and integration with GPS and other navigation sources. Publications are also being digitized and distributed on CD-ROM by NIMA. The Navy Lessons Learned System exists, but it is underutilized by the navigation community. Designed to be a low cost, low maintenance system, it does not provide the search tools, graphics or data capable in today's information age. Since this initiative to digitize is well underway by NIMA [Ref. 19], the focus of our research has been on filling the information void for Navigation Planning. Ideally, the data gained from the users in this survey will help shape the future collection and dissemination of navigation information.

Every idea mentioned within the surveys is technologically feasible. The fleet is willing to embrace a better system. The primary challenge for the remainder of this thesis is to develop a system recommendation that maximizes data interchange while

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minimizing development and maintenance costs. The secondary challenge is to make it simple so that it gets used. The third and final challenge is to make it compatible with existing systems so it is not yet another stovepipe.

D. SUMMARY OF REQUIREMENTS ANALYSIS

Many of the responses included typewritten letters, provided literature on commercial products or named points of contact for further research. The overall quality and quantity of data returned exceeded our expectations. Although we envisioned conducting comprehensive statistical analysis comparing groups of data, the large sample sizes and consistency across groups negated much of the statistical analysis. Conducting the survey and interpreting the vast quantity of information provided the following tangible benefits:

- Validated many assumptions

- Allowed user input into system development

- Provided direction for a new prototype navigation planning tool

- Showed how willing the fleet is to embrace new technology

It also may provide the intangible benefit of improving future acceptance and use of a new Navigation Planning System should it get introduced to the fleet.

Taking into account the survey results, a system architecture that meets the needs of the fleet would contain two overlapping systems:

- A relational database updated with current information and distributed to the fleet periodically (quarterly) on CD-ROM. Monthly diskettes could be distributed with information deemed critical.

- A Client-server architecture with the most current database on the server to allow clients access to the newest information through a browser. Last updated dates could be used liberally to minimize connectivity times for ships at sea.

An absolute key to making this database concept successful is obtaining quality inputs from the fleet. Formatted surveys to capture feedback would be an integral part of the

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database. This data along with digitized pictures could be sent via diskette or electronically uploaded when feasible. With IT-21 mandating Office '97 as the software of choice [Ref.13], Access was chosen for our prototype database. IT-21 also solves the need for personal computers with more than enough power to run such an application.

III.   MIGRATION ALTERNATIVES FOR A NAVIGATION PLANNING SYSTEM

A.   DEVELOPING ALTERNATIVES

Migrating from the current manual navigation planning method to an automated method should be done carefully. The current repository of data and the process of collecting maritime navigation information in the form of hard copy charts, publications, updates, and computer products has evolved in the U. S. Navy over two centuries. In this chapter several different migration paths (manual to automated) will be explored, and some of the key pros and cons of the options will be weighed. Fleet users, in one form or another, suggested all migration options (Appendix E).

The current manual method of navigation planning (described in Chapter I) has its greatest strength in that it is accurate and reliable. U.S. Government agencies that collect, produce, and disseminate navigation information are well established and have spent many decades developing the know-how and infrastructure to accomplish their mission. The greatest weakness of current navigation planning is that it is extremely labor intensive. According to fleet users, the average "unit" (e.g., ship, submarine, or afloat staff) spends nearly 35 man hours per week keeping their hard-copy navigation products (charts and publications) corrected and up-to-date (Chapter II Table 2-10). When ships are operating at sea, many more additional hours are spent collecting and filtering this up-to-date navigation data into informative navigation plans and briefs. Alternatives therefore should be developed to use state of the art computer technology to help reduce the number of man-hours being spent by fleet units on the maintenance and assembly of navigation information.

A broad range of naval personnel, ranging from Navy captains (pay grade O-6) to third class petty officers (pay grade E-4) provided the fleet survey feedback discussed in Chapter II. Based upon this fleet feedback, there is overwhelming support for migrating from the current cumbersome manual navigation planning process to a more efficient

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automated method (Appendix E). This need to "digitize" all aspects of navigation is also well recognized by NIMA, and has been clearly articulated in their publication entitled *Digitizing the Future*. In addition, a new navigation demonstration software package called the Full Utility Navigation Demonstration (FUND) has just been released by NIMA in December 1997. This program reportedly accepts digital nautical charts and has some voyage planning capability [Ref. 20].

B.   TECHNOLOGY OPTIONS

Several ship navigation programs, both military and commercial, already exist in the fleet, as described earlier. The key functionality which should be added to current voyage planning tools is the ability to instantly access and accept any and all structured and unstructured digital navigation products, ranging from nautical charts to publications to database information.

The following existing computer technologies are appropriate for these tasks:

1.   Computer Hard-Drive Resident Program

The Naval Sea Systems Command (NAVSEA) Navigation Sensor System Interface (NAVSSI), described earlier, is an example of a navigation program designed to permanently reside on a shipboard computer hard-drive. NAVSSI was designed as a software layer to ride on top of the Joint Maritime Communications Information System. JCMIS runs aboard ship on the NAVSEA TAC-3 or TAC-4 computer workstation, which uses the UNIX operating system. Other hard-drive resident navigation programs are designed for personal computers, such as the Cap'n program.

All hard-drive resident programs can operate in a stand-alone mode on a single computer, and many are designed to be accessed and used remotely via distributed computer networks and client-server configurations.

The benefits of maintaining a navigation program on the local hard drive include [Ref. 21]:

- If the computer network suffers a casualty, it can still operate in stand-alone mode on the local platform until the network is restored.

- The security of the program and data may be enhanced if robust security features and access controls are maintained on a "local" computer (and not across the entire network).

- Better control over standardization of software can be accomplished with hard-drive resident programs versus Intranet or Internet available programs, which may have many hundreds or thousands of users. Current rigid U. S. Navy version control and distribution of IT-21 compliant software helps to support the concept of standardization [Ref. 13].

The disadvantages of a Hard-Drive resident Navigation program and data include [Ref. 21]:

- Islands of information - different platform capabilities

- Possible multiple data formats - hard to share data

- Multiple interfaces

- Multiple protocols

- Support costs for each platform/station

2.   Removable Media Updates to Hard-Drive Resident Programs

Any hard drive resident navigation program must have some means of updating or revising both the operating program and the navigation data used. This is necessary because navigation data is often inherently perishable, and software is always being improved. For example, a meteorological phenomenon such as a tropical storm might completely change the characteristics of a Caribbean port's ship berths. Storm-driven silting may occur in some areas of the inner harbor, and this condition would need to be immediately promulgated to potential visitors to the port. A "Notice to Mariners" (NOTAM) message would currently be broadcast to the fleet to inform ships of the silted harbor hazard. In addition, the storm may cause other long-term changes to the port and

services available there which may affect navigational publications covering the region. Herein lies the need to be able to update the navigational data resident on a computer hard drive, which may include charts and port publications for our example Caribbean port.

One method of updating the hard drive would be to distribute a floppy disk update to the appropriate ships. The standard 3-1/2 inch floppy disk is removable and may contain up to 1.44 megabytes (Mb) of data after formatting. Other removable storage media which could be used for updates include the 3.5 inch zip drive, which can store 100 Mb of data, and the 4.75 inch ISO 9000 format Compact Disk (CD), which can store up to 660 Mb of data [Ref. 22:p. 130]. All of these portable storage devices would have to be mailed or otherwise shipped to an afloat command to periodically update navigation software and data. Fleet feedback has indicated that such updates should occur anywhere from monthly to annually, with quarterly revisions being the most common recommendation for routine, non-emergency updates.

CD optical disk technology has become popular in the 1990s, because it is inexpensive and so well suited for storing massive amounts of data. CDs were designed to store encoded digital information, such as up to 100,000 pages of text [Ref. 23:p. 101]. This is over 400 times the 3.5-inch high-density floppy disk storage capability. In addition, plastic CDs have other advantages over floppy disks: they are less vulnerable to magnetism, dirt, or rough handling [Ref. 22:p. 131]. Several different forms of CDs exist. CD-Read Only Memory (CD-ROM) is the most common and is intended for mass distribution of data. Other forms of CD technology include CD recordable (CD-R) which are write once, read many and CD read-writeable (CD-RW) which have the same functionality as floppy disks. CD Optical jukeboxes are a new innovation, which offer an inexpensive way to archive huge amounts of data with interchangeable libraries of stacked CDs.

3.   World Wide Web or "Online" System

Yet another automated migration alternative might be to make the navigation planning program and data available through a large computer network such as an intranet or the Internet. By taking advantage of a distributed computing environment and a client-server architecture, any number of fleet users could conceivably capitalize on the information "power" available from a modern World Wide Web navigation tool, for example. Updates could be rapidly transmitted over a network to a large number of users, thereby eliminating shipping costs and getting the information to users much faster.

Other advantages of a Web-based Navigation Program and data [Ref. 22: pp. 4-5]:

- Platform independence
- Multiple data formats can be accommodated
- Single interface
- Uses common protocols
- Easier to disseminate and share information
- Minimizes ongoing support costs
- Permits leveraging scarce computing resources

C.   OTHER ISSUES WITH A WEB-BASED NAVIGATION PROGRAM

1.   Bandwidth

Any computer networks designed for use at sea must be designed with bandwidth in mind. Due to the inherently mobile nature of sea-based forces, satellite and long-haul radio links must be employed for information exchange. Appropriate radio frequency bandwidth must be allocated within the available spectrum to support the transmission and reception of massive amounts of data.

In addition to bandwidth availability, the information capacity of the system is an important design consideration. The current typical "low-end" at-sea computer network has a T1 bit rate: 1.544 Megabits per second (MBPS) [Ref. 24]. This is being improved

as new initiatives to increase capacity are integrated into the fleet such as the Automated Digital Network System (ADNS).

2. System Security and Data Vulnerability

Networked computer resources and data have an inherently increased risk of corruption and unauthorized access due to the large number of users who have access to the network at any given time. A stand-alone personal computer typically has fewer users with access to it and therefore has a lower associated security risk. The current manual hard-copy navigation planning data also has fewer users who have direct access to it than if this same data were digitized and made available to the masses on a large network. Although the vast majority of navigation planning software and data is unclassified (with much of it commercially available or in the public domain) there exists a significant data vulnerability issue. If this unclassified navigation data were placed in an open database and made available to the public via the World Wide Web (WWW), a computer "hacker" might gain access to the database and alter critical information. For example, a chart that shows a reef near a port entrance could be modified to delete the reef and show safe water in its place. An unsuspecting mariner might access this corrupted data and use it in good faith to navigate into port, subsequently running aground on the "ghost" reef. This example illustrates that although navigation information is wholly unclassified, the database or other data sources must be protected to prevent unauthorized access or malicious tampering. The safety of marine navigation would therefore largely depend upon the strength of the database security features. At a minimum, the data source (database) should be designed with appropriate computer security features such as robust encryption (to protect the data) and password protection to validate authorized users to the system. The ideal system would also include a secure computer network to permit safe data transmission and reception. If the system were to migrate to the SIPRNET or NIPRNET, the security and password schemes used by

similar applications on those networks would be sufficient for a full-scale fleet version of GatorNet.

3. Connectivity

Numerous fleet users expressed a concern that a Web-based navigation-planning tool would not be available to them because they do not currently possess the needed telephone lines, personal computers, or network access necessary to support such a tool (Appendix E). Fortunately, the move to bring the Internet and more networked computer resources to sea has begun, as evidenced by initiatives such as SeaNet, IT-21, and ADNS, among others. The newest surface ship classes such as the DDG-51 and LHD-1 are being built with high capacity computer networks, although this does not solve the submarine's connectivity problem while submerged. This may be the strongest argument yet to design any navigation migration system so that all needed data and software is contained onboard (locally), such as with the CD jukebox method. Periodic updates could still be sent via an outside network, which a submarine could access for updates when it is surfaced.

D. SUMMARY

A significant benefit of using network technology in conjunction with databases and other incompatible data formats is that a common interface can be achieved for multiple heterogeneous platforms [Ref. 25]. This is the beauty of such an arrangement: Vast quantities of distributed information can be "pulled" by a user into a single, easy to use Web interface. The benefits of using Web and database technology can be summarized as follows:

> The recent popularity of the World Wide Web has created a massive increase in both the supply and demand of Web-based technologies. However, the HyperText Markup Language used to construct the Web has limitations that challenge information content providers who want to supply current, up-to-date information with minimal administrative overhead. A powerful, extensible solution to many of these challenges is

the use of a database as a *back end*, or data source, for Web applications. Combining the Web with a database maximizes the strengths of its components. From the Web perspective, this combination offers user friendliness, cross-platform compatibility, and high-speed prototyping capabilities. From the database perspective, it offers relational data manipulation, high-speed search capabilities, and industrial grade data input and retrieval [Ref. 26].

This migration path was chosen for the GatorNet prototype development.

IV. "GATORNET" RAPID PROTOTYPE

In order to prove the "GatorNet" concept, a rapid prototype was developed to demonstrate functionality and design possibilities. Although the World Wide Web (WWW) may not be the medium of choice for the final product, it allowed a convenient means to provide quick exposure of the prototype to decision-makers and achieve widespread visibility with Navigators throughout the Navy. The WWW also provides the perfect forum to easily distribute the prototype to widely disbursed clients and gather feedback for improvement. With these benefits in mind, a web based application was chosen for the prototype with the understanding that distributed CD-ROMs may prove more cost effective for the actual system until bandwidth, security, connectivity and standardization issues are resolved. These issues will be addressed in the following chapter.

A. PROTOTYPE OVERVIEW AND GOALS

Several areas were identified from the fleet survey as being candidates for proof of concept within the prototype. To manage the scope of the prototype, three primary areas were chosen. The first was visually depicting aids to navigation and harbors since it exploits a new concept that does not readily and widely exist in current planning. The second was developing a Navigation Lessons Learned Database that allows quick and easy access with more functionality than the existing NTIC CD-ROM or Port Directory publication systems. The third was creating port specific web pages that can be used to gather and disseminate timely information. To educate the user on the purpose behind "GatorNet", survey results and thesis chapters were made accessible on the prototype site. Links to other navigation related sites were also included.

San Diego, California was chosen as the primary harbor for data collection. As the largest naval homeport on the West Coast, it provides a familiar example to a large number of potential users. San Diego also provides a rich number of aids to navigation.

The true value of "GatorNet", however, is providing a wealth of information on a port not yet visited by the navigator.

1.   Visual Depiction of Navigation Aids and Harbors

With the advent of Differential Global Positioning Systems (DGPS) on each coast of the United States, an argument could be made that the accuracy of this system (within meters) will one day make traditional visual navigation procedures (triangulation through lines of position) obsolete. With less than 100 percent reliability and less than total coverage throughout the world's harbors, that day is well into the future. Given that visual navigation will be required to guarantee the safety of our ships, it stands to reason that a better prepared navigation team is less likely to hazard the ship and its crew. Preparation can come in many forms. Historically, the navigation team researches restricted water transits in publications such as the Port Directory, Sailing Directions (foreign ports), Coast Pilots (US ports), Fleet Guides (approximately 15 highly visited Naval Ports), and through pertinent message traffic.

Several of the publications contain aerial photographs for the larger ports to give an overview of the harbor layout. Occasionally they depict a primary navigation aid such as range markers to the main channel or a lighthouse. A thorough repository that includes pictures of multiple navigation aids that have been successfully used by other ships would allow the team to better plan and preview their transit. In addition, comments by navigators on aids that may appear useful on a chart yet are difficult to acquire could greatly assist the team. Imagine having a brand new seaman shooting lines of position for a Commanding Officer and Navigator's first visit into the busy port of Hong Kong. The chance of locating and providing a timely bearing are increased tremendously if that seaman has a chance to view photos of the navigation aids prior to making the transit.

Still pictures were chosen for the prototype due to storage and bandwidth considerations. Several pixel dimension and JPEG compression factor combinations were experimented with to produce a good quality picture while minimizing file size. The

primary goal was to keep the file size to15Kb to minimize user download time. With a JPEG quality factor of 100 (Corel Photo-Paint's scale ranges from 2-High to 255-Low), the color pictures used throughout the prototype averaged 10-15Kb (image size approximately 3 x 5 inches on screen with 800 x 600 resolution). Several pictures were cropped with smaller dimensions depending on the navigation aid's size and characteristics to further reduce file size. The pictures were taken with a 35mm camera, scanned into Corel Photo-Paint and sharpened ten percent to show greater detail. When developing the web pages, keeping the total page size less than 20K resulted in a reasonable page transfer time of less than ten seconds given a meager 2K/sec-transfer rate that is typically experienced through a remote access modem connection. If the ultimate GatorNet product were to include archives of photographs on a periodically distributed CD-ROM, larger and higher quality pictures could be included. Pictures available "online" could be limited to urgent ones dealing with safety issues, corrections to existing pictures, or those that are deemed crucial and add significant clarity to a confusing navigation aid.

2.   Lessons Learned

As evidenced in the survey results, only 36% of the commands surveyed maintain organized lessons learned files on port visits. With a navigator holding the position usually less than two years, there is considerable "corporate knowledge" that is lost. By improving the method for collection and increasing the repository of information available to the navigation team, this knowledge can be captured and overall safety improved.

In designing the GatorNet lessons learned applications, the following improvements were desired:

- Increased volume of lessons
- Quicker turnaround of information and easier access
- Capturing author information and establishing a user database to enable contact through e-mail for future amplification should users have questions

- Quantitative orientation to provide precise, measurable data points for users
- Graphic orientation and the ability to correlate lessons with photographs

Searching the entire unclassified October 1997 NTIC Series A CD-ROM yields less than ten robust port visit lessons dating back through early 1996. The NLLS Fleet Management Sites (FLTCINCS, CINCUSNAVEUR, and COMUSNAVCENT) validate new lessons and review the database for currency and adequacy. Lessons are automatically expunged from the database after two years unless revalidated by the Management Site. Several smaller ports are not visited with great frequency, and although desired, ships are not always required to submit a lesson learned. Due to Secret classifications, the NTIC CD-ROMS usually reside within the Intelligence spaces on a ship and are not easily quickly accessible by the standard user. This combination produces the sparse number of navigation lessons present in the current system. Survey results demonstrated that the system is a complete failure with respect to navigation (47% of respondents had never used the system and 36% use it less than once a month).

The Port Directory contains reports from ships on virtually every port visited by naval ships, but many are very dated and the reports are exclusively text oriented. Ships are periodically tasked to provide a report to update the directory. The reports are cumbersome and require inputs from several departments throughout the ship. Typically no feedback is received and new reports are not incorporated until the annual update. By providing users standardized forms (GatorNet uses a modified and scaled down version of the submission form for the Port Directory) that are simple to complete, the concept is to capture as many value added lessons possible after each evolution. Keeping the process simple increases participation. This can be accomplished if a Navigator can sit down at a readily available personal computer, quickly fill out pertinent comments, attach a picture if necessary from a digital camera to clarify the situation, and electronically submit a completed form. Building a robust repository where contributors can quickly see the fruits of their effort and benefit from other users is the key to a successful system.

3. Port Data

There are several areas of interest in addition to navigation for ships preparing to enter port. Much of the time sensitive and ship dependent information is supplied through message traffic in reply to the logistics request (LOGREQ) message sent before entering port. Searching the WWW for information on world ports yields considerable information in a variety of formats. The intention behind this portion of GatorNet was to show the functionality that could be achieved through simple, static web pages. Area commanders could use these web pages to disseminate pertinent information and provide guidance to ships preparing to enter port. The potential use is unlimited and could range from pertinent instructions or regulations, a calendar of events, schedules for opareas, weather forecasts, or points of contact.

B. PROTOTYPE FUNCTIONALITY

The prototype is designed to be as user-friendly and as self-explanatory as possible. On-screen examples are provided for clarity, and help buttons are available if necessary. Image icons, point and click maps, and drop down lists were used extensively to provide the inexperienced web user a simple interface.

1. "GatorNet" Homepage

The GatorNet homepage is displayed in Figure 4-1. It provides links to the major areas of the prototype mentioned previously. It also provides the user with a statement on the purpose behind the prototype and who to contact if there are questions.

2. Ports

Selecting the Ports Icon presents the user with a world map for the user to view and select a port. After selecting the Southwestern United States, the user can gain access to the prototype site of San Diego. Figure 4-2 contains the San Diego harbor navigation frame presented to the user. The Ports section of the prototype is one of the primary

methods of accessing pictures of navigation aids. For the prototype, sections of charts 18765 and 18773 were scanned to assist the user in correlating pictures with aids.
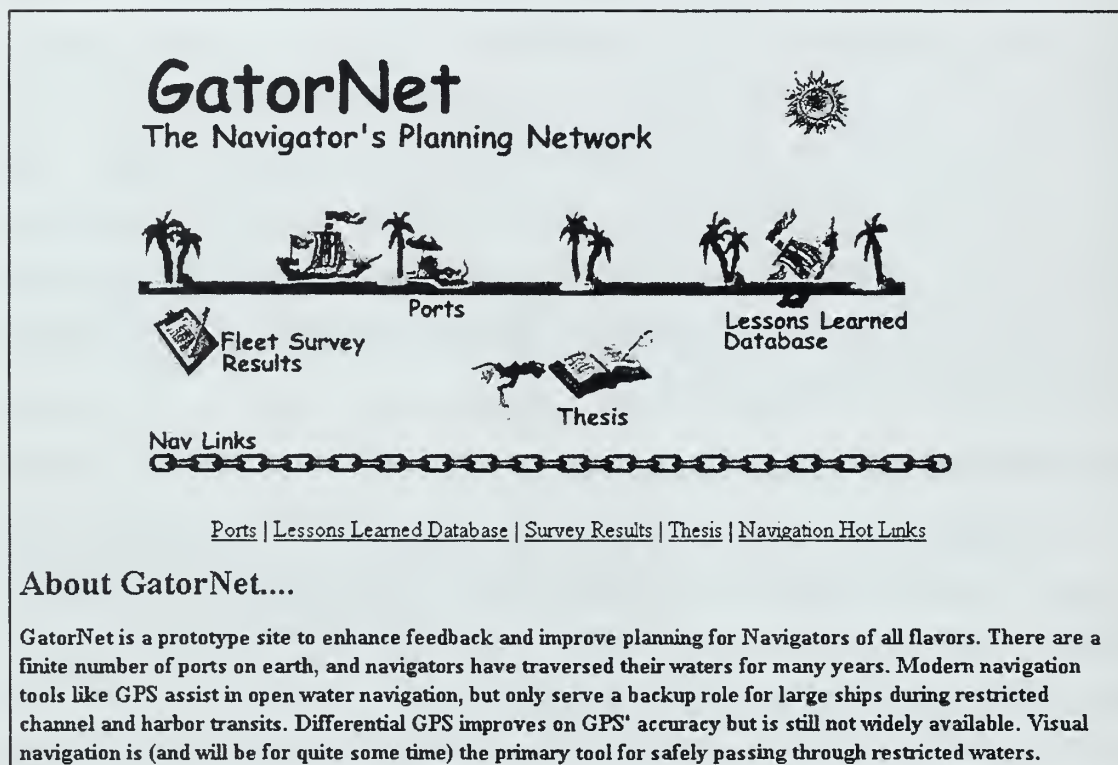
Figure 4-1. "GatorNet" Homepage

San Diego is a lengthy harbor transit, and to maintain enough detail yet minimize download time it was necessary to create several web pages containing portions of the transit. By selecting an outlined portion of the channel, the user is presented with Figure 4-3. Aids that have pictures associated with them are highlighted and contain a link to an additional web page as depicted in Figure 4-4. If necessary, the pictures can be annotated before posting to clarify the actual navigation aid, describe where the picture was taken from, or present photographer comments. A user with an actual harbor chart can easily correlate the digital image to the actual chart. As photos are submitted, it is a fairly straightforward task for the administrator to highlight the chart and create new links.
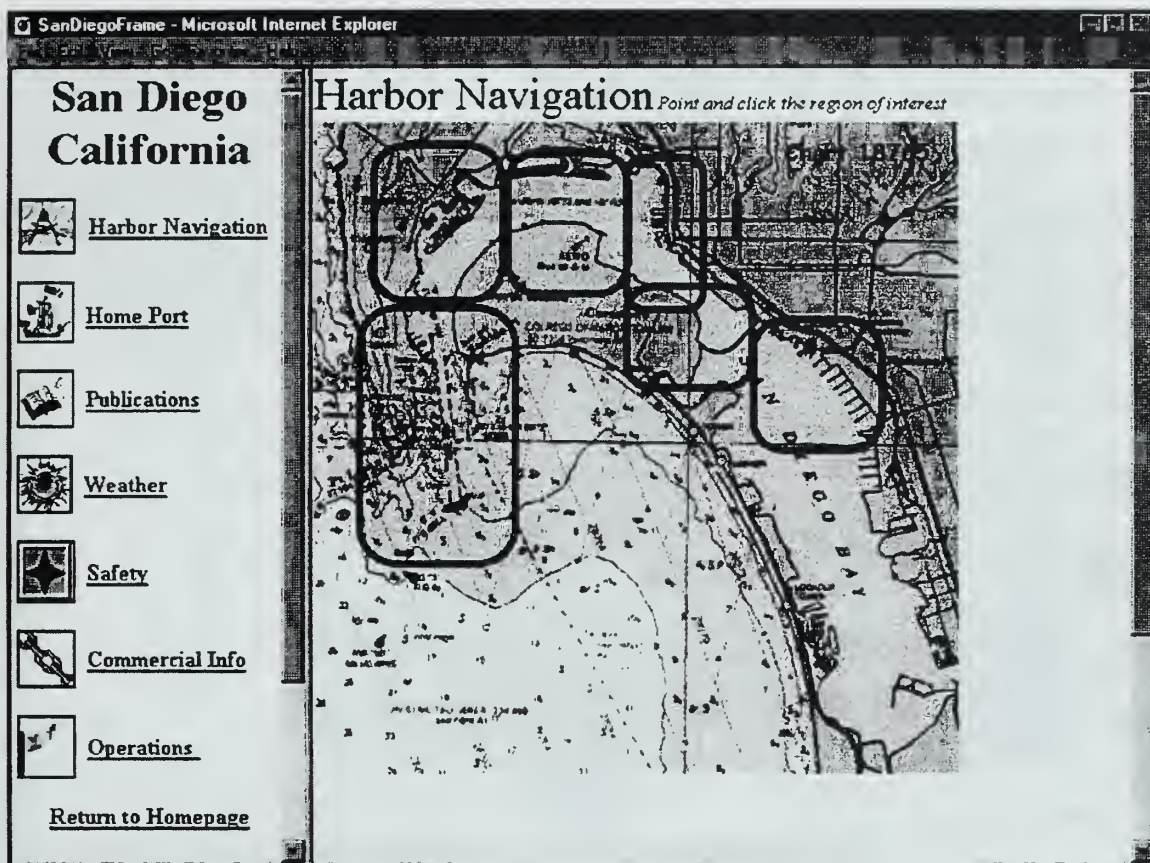
Figure 4-2. San Diego Home Page

The remainder of the icons on the Ports web page can be structured to contain pertinent information. *Home Port* could contain information from the area commander, links to local command web sites, or training information. *Publications* might contain downloadable Portable Document Format (PDF) documents such as Fleet Guides, portions of navigation publications (Sailing Directions or Coast Pilots) pertinent to that port, or other relevant instructions or regulations. For the San Diego prototype, *Weather* contains HTTP links to local area forecasts and tide information. The final product could contain a tide and current program, links to weather forecasts, sea-state observations or sunrise/sunset computations.
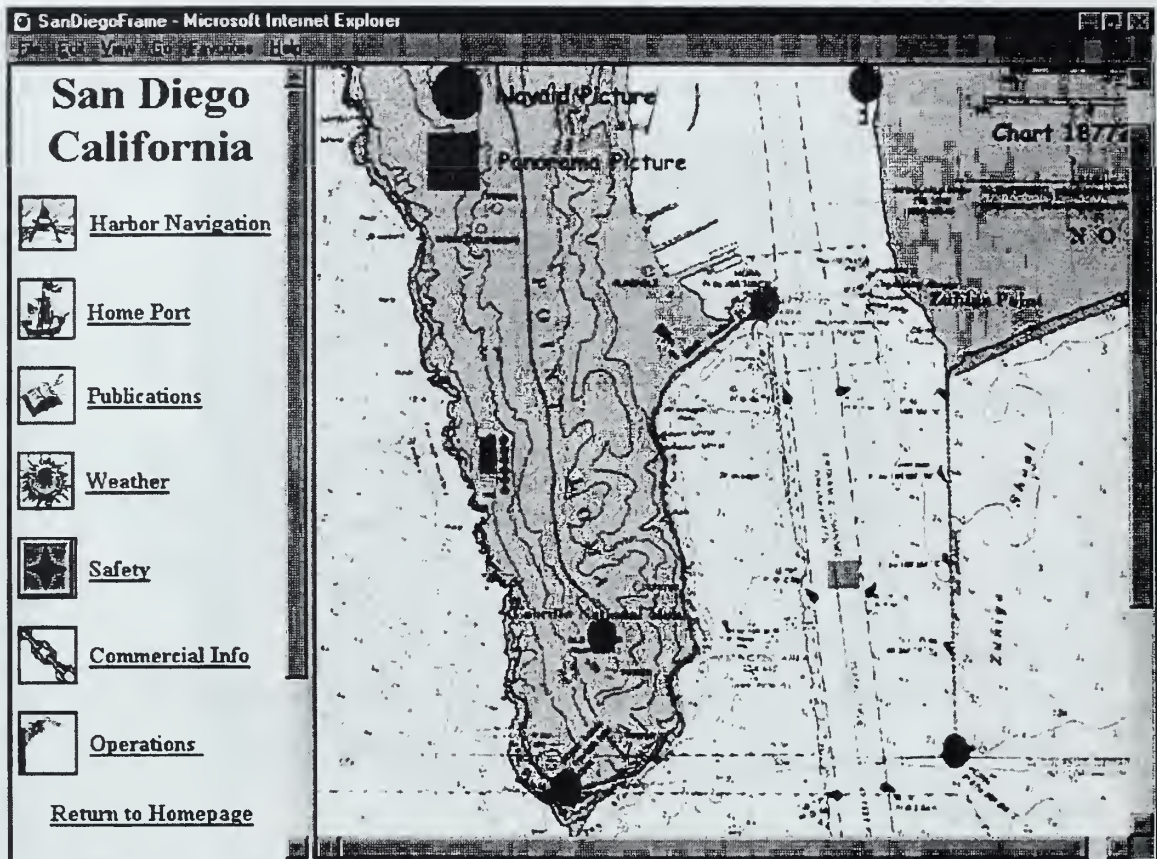
Figure 4-3. San Diego Entrance

Safety could contain Local Notices to Mariners, pertinent Hydropacs or Hydrolants, phone numbers for oil spill response teams, or local mishap procedures and phone numbers. *Commercial Information* may show local street maps, phone numbers for tug or pilot services, provide entertainment or restaurant recommendations, or instructions on water and waste services. *Operations* is an area that could list schedules for exercises, communications, or training information. The ultimate design is only limited by the imagination.
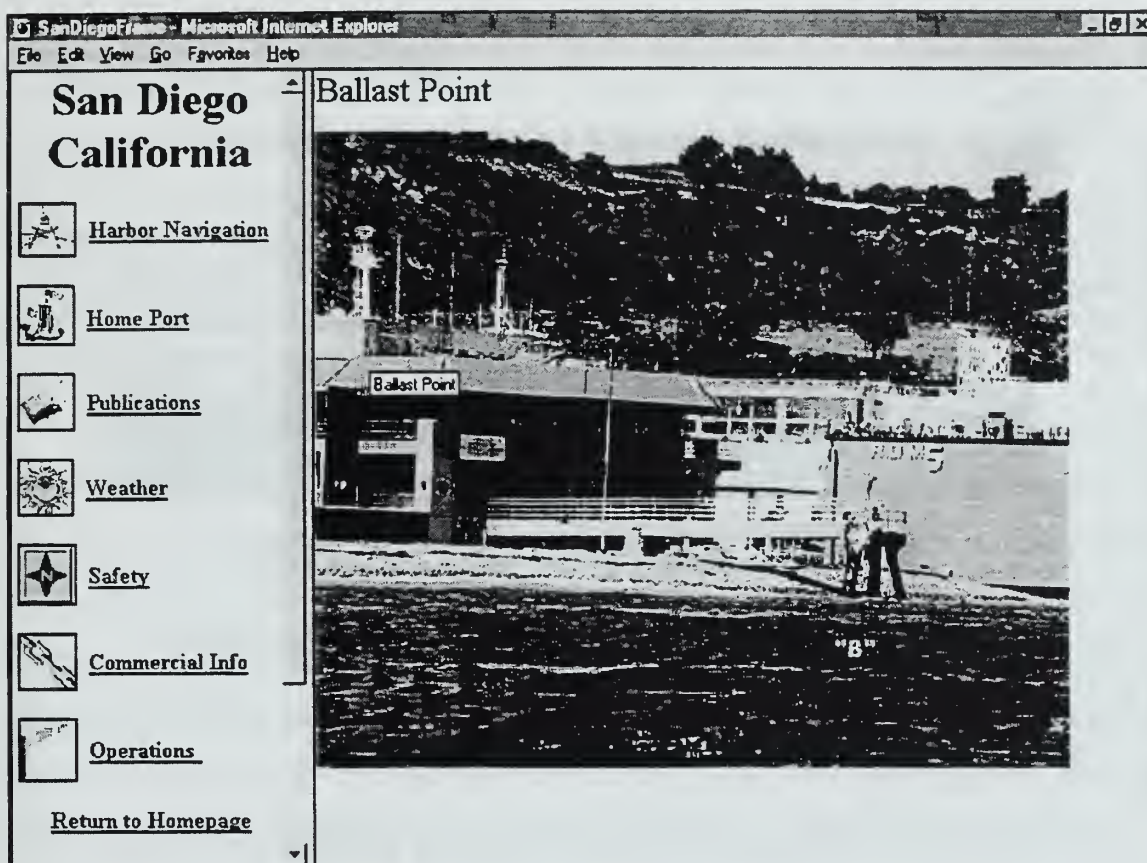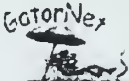
Figure 4-4. Ballast Point Navigation Aid

3.   Lessons Learned

As the user clicks the lessons learned icon on the GatorNet home page, Figure 4-5 is displayed. Although named a "lessons learned database", it is a relational database containing users, navigation aids, photographs, comments and voyage lessons. The rapid prototype contains five applications (CGI scripts) for querying Units, Lessons Learned, Photographs, Photograph Comments, and Navaids. It also contains three applications for Voyage Entry, Photo Submission, and Photo Comments. The user accesses these query forms by pressing the appropriate button.

Figure 4-5. Lessons Learned Main Page

Since the only photographs currently populating the prototype database contain navigation aids, both the Navaid and Photograph Search buttons display Figure 4-6.
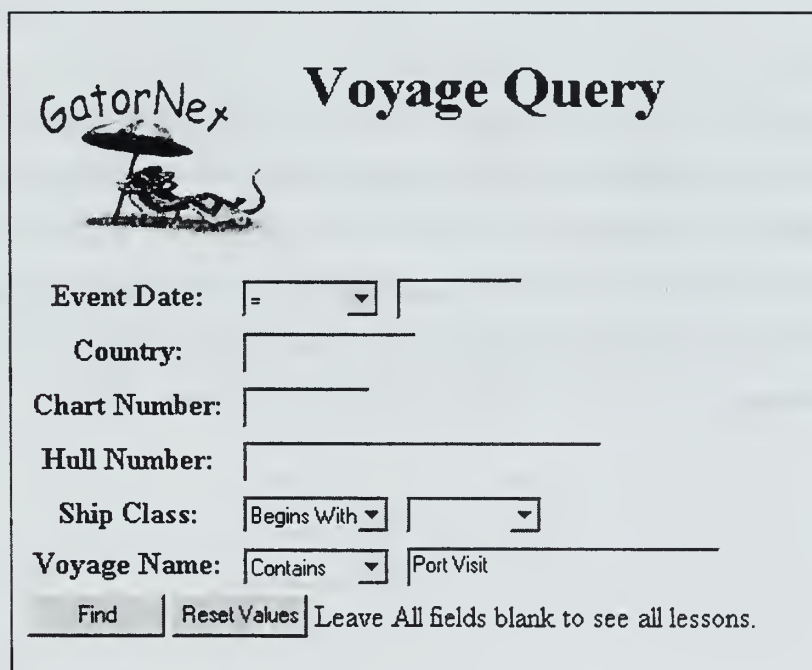
Figure 4-6. Navaid Search

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In the final product, pictures of tugs, piers, fittings, or even equipment like brows or cranes could populate the database. Figure 4-7 illustrates the query form for a "Lessons Learned Search". All query forms have a similar look and feel. If left blank, all records will be displayed. To narrow the search standard operators (>,=,<, contains, begins with, etc.) can be used for matching. Once the "Find" button is selected, matching records are returned as in Figure 4-8. The user can "drill down" to gain amplifying information as in Figure 4-9 by selecting the hyperlink field.

To minimize response time, the picture is a selectable button. A user can provide comments on the picture if deemed necessary as in Figure 4-10. This allows a mechanism for feedback and allows future users to gain more confidence that the picture they are viewing is in fact the proper navigation aid. A radio button scale from one through five is provided when submitting pictures or when commenting on pictures. Since an inaccurate picture could be a potential safety hazard (misinformation could be more detrimental than no information at all), this confidence ranking system and the ability to provide additional comments are two methods to mitigate potential problems.

Figure 4-7. Lessons Learned Search

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When submitting either a lesson (voyage, harbor transit, anchorage, exercise, etc.), photograph or comment into the database, the records are added to a temporary database where the administrator can sanitize the information. Although an extra step for the administrator to validate and transfer records to the master database, this provides a measure of security against user mistakes, intentional misinformation or spoofing, or poor entries. An Access '97 macro could easily be written to transfer validated records and append the master database. All queries access the master database that contains the sanitized information.

Figure 4-11 contains an example of the Photo Submission Form. The same user information is collected when entering a photograph, lesson or comment. By collecting the phone number, point of contact, and e-mail address, a future user should be able to quickly contact the originator should there be questions. With the proliferation of e-mail, the day when service members can easily be located even after transferring to new commands is at hand. This added feedback mechanism is invaluable, and would have widespread application beyond navigation.

Pictures can be related to specific voyages or can be entered independently. When entering voyage information, a voyage identification number (the database table primary key) is provided to the user for reference when submitting photographs (9999 is used as the default if the photograph is submitted independently). After submitting a photograph, a photo identification number is provided for annotating on the back of a mailed photograph or attaching to an electronically submitted photograph. These measures provide the database administrator with a mechanism to keep voyages, photographs and data records correlated.

Figure 4-8. Matching Record Form for Navaid Search

Figure 4-12 shows the initial portion of the details from a sample voyage entry. Other pertinent navigation information such as visual navigation, radar navigation, tug, tides/currents, depth and many other areas are collected on the voyage entry form. If a field is left blank during record submission, the field is not displayed when querying. Memo field data types are used to store comment information and minimize the size of the database. Only the amount of information typed in by the user is stored and not a fixed record size.

Navaid Details

GatorNex

NavAid Name:	Entrance Range Front
Type of Navaid:	Light
Chart Number:	18773
Lat/Long:	3242.3N11714.0W
PubDescription:	L. List: No. 1500; Front Range Q G, 22 ft, KRW on white column; KRW on skeleton tower; visible 4 deg each side of rangeline

Click for picture

Comment on Picture

View All Comments

Figure 4-9. Matching Record Detail

Photo Comments

GatorNex

Hull Number:	LPH-11 (IE LPH-11)
Ship Class:	LP
E-Mail Address:	gator@neworleans.navy.mil
Phone:	DSN 656-1015
Unit Point Of Contact:	Karl Thomas
ExtraComments:	Once established on the 356 leg, channel buoys can be used to help locate the range. Range is typically visible to the naked eye before the

Confidence: Low ○ 1 ○ 2 ○ 3 ○ 4 ● 5 High

Save   Reset Values

Figure 4-10. Photo Comments Submission Form

Photo Submission

GatorNex

Hull Number: [   ] (IE LPH-11)

Ship Class: [AD ▼]

E-Mail Address: [   ]

Phone: [   ]

Unit Point Of Contact: [   ]

Chart Number: [   ]

Voyage Number: [9999] (Change only if assigned a new number when enterring Voyage feedback form)

Lat/Long: [   ] (IE 3252.3N11714.2W)

NavAid Name: [   ]

Type of Navaid: [Light ▼]

Date Picture Taken: [YYMMDD] (Must enter numbers or will receive an error!)

Photographer's Comments: [   ]

Confidence Level: Low ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 High

(How confident are you the picture is the Navaid specified?)

Figure 4-11. Photo Submission Form

Voyage Details

GatorNex

Event Date: 970508

Chart Number: 21338

Hull Number: PC-8

Voyage Name: Puerto Vallarta Port Visit

Country: Mexico

Lat/Long: 2039N10515W

Pilot Ranking: 9

Pilot Comments: PILOT IS COMPULSORY. PILOT IS REACHED VIA BB CH 16 "CAPITANIA, PUERTO VALLARTA." TRANSLATES TO "HARBOR MASTER, PUERTO VALLARTA." PILOTS SPEAK ENGLISH. PILOT BOARDED 1 MILE SOUTH OF BREAKWATER.

Figure 4-12. Lesson Learned Search Result

4. Survey and Thesis Results

In order to disseminate the large volume of information collected in the fleet survey, the results are posted on the GatorNet prototype. Links are provided to the graphical and tabular results of Chapter II and the Appendices. The narrative comments listed in Appendix E are also provided. Users viewing the survey information are free to make comments, adding to the feedback available to future GatorNet developers. The "thesis results" section of the prototype contains an HTML version of this document accessible by chapter.

5. Navigation Links

While conducting research and developing the GatorNet prototype, several useful web sites were discovered. These sites are organized on the Nav Links page. This could be an expanding and evolving page containing links to ports, users, navigation products, navigation research and development projects, or anything else pertinent to navigation.

C. SEMANTIC OBJECT MODEL

When designing the database structure to contain the repository of information for the prototype, the semantic object model was chosen over the entity relationship model. Semantic Object modeling is particularly well suited for the bottom-up development approach taken toward the rapid prototype [Ref. 27:p.47]. This choice was also made due to the availability of and familiarity with the SALSA schema generation software.

The initial database structure was a vast, all encompassing effort to design a database that could accommodate a full-scale GatorNet implementation. Approximately 15 objects were used and included navaids, charts, ports, piers, pilots, hazards, individual users, and units to name a few. Several of these objects had group attributes and attributes with maximum cardinalities of "N". Once the schema was generated, well over 30 tables existed. Schema generation was not difficult, but as applications were

developed to access the relational tables it quickly became apparent that a greatly scaled down version would be needed to manage the scope of these applications and complete the rapid prototype.

When using relational tables, foreign key management becomes critical. As the number of objects and relations increase, the application development becomes increasingly difficult. The other extreme is to use a flat file scheme, but this results in considerable data redundancy. Figure 4-13 contains the five objects used within the prototype and their associated data attributes. These objects provided ample information to prove the GatorNet concept.
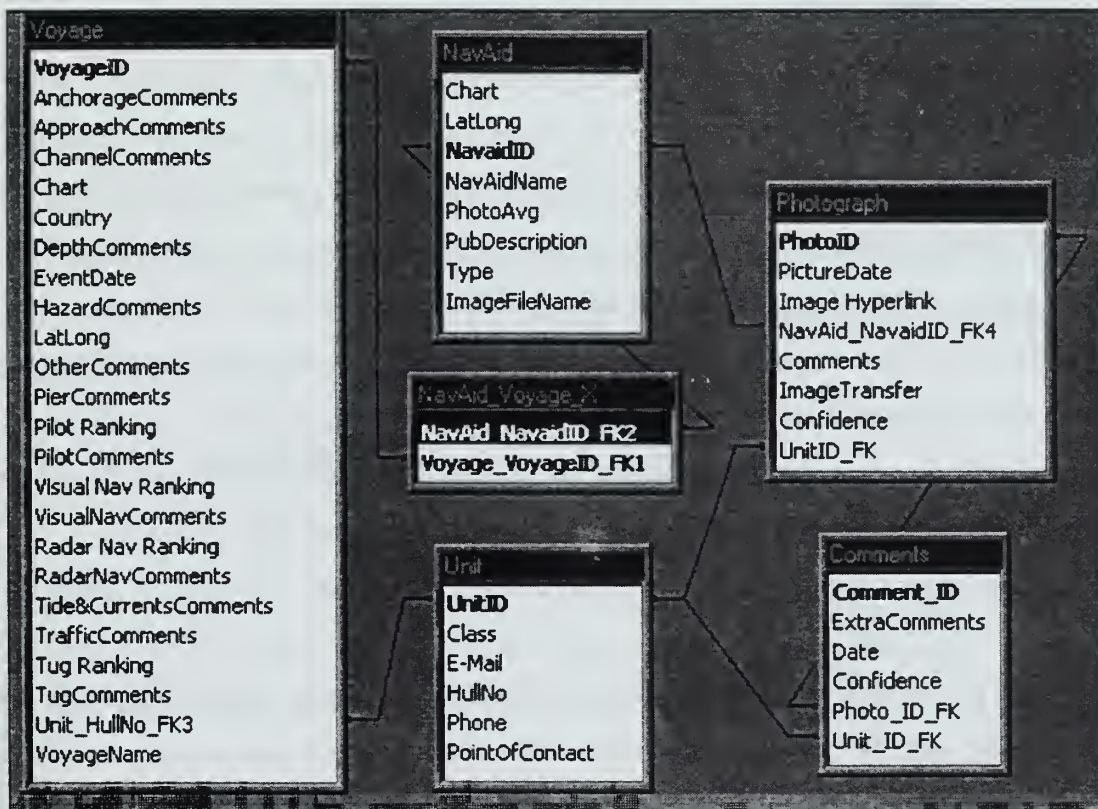
Figure 4-13. Database Objects and Relations

D. RELATIONAL DATABASE

Access '97 was used for the relational database software for several reasons. The primary reason was familiarity and availability of the software package. Additionally, since Microsoft Office '97 has been mandated as the standard for IT-21 [Ref. 13], it made

sense to use a software package that will be widely available throughout the fleet. Furthermore, since Front Page was the web development software and Microsoft Internet Information Server (IIS) the web server, using solely Microsoft products decreased chances for incompatibility.

To minimize complexity, auto-generated primary key integers were used for each object. Prior to each new record entry, a direct DBMS action is performed by the Tango middleware (discussed later in the chapter) to determine the last record in a table. The ID is incremented by one and a new record created.

1. Unit Table

In the prototype, every time a user enters information for a new photograph, comment or voyage a record is added to the Unit table. This creates obvious data redundancy. In the final product, a password and user-ID scheme would end this drawback and keep the administrator from having to purge the Unit table of duplicate records while correcting the unit foreign keys within other tables.

Both *Hull Number* and *Ship Class* attributes exist to allow searches on either item. A more robust system would accommodate staffs and individual users. A unit can be related to multiple photographs, comments, or voyages. Therefore, the foreign key of the unit resides in those tables.

2. Photograph Table

The photograph table is straightforward. The *Confidence* attribute stores a 1-5 value assigned by the photographer rating how sure that particular picture shows the actual navaid. This allows a degree of reliance to be placed in pictures by navigators using the system. The *Image Hyperlink* contains a hyperlink to the JPEG filename. The *Image Transfer* attribute is not functional, but was designed to store a binary value depending if the image was electronically submitted or mailed to the database administrator. The foreign key for Navaid is in the Photograph table since a navaid conceivable could have more than one picture submitted.

3. Voyage Table

The attributes contained in the Voyage table allow a basic lesson learned format geared toward a restricted water transit. The multiple *Comments* attributes use the memo field and allow text based discussion. The *Ranking* attributes contain an integer between 1-5 as selected by the user with a radio button. This ranking mechanism could be used to collect opinions over time and develop statistical data on tugs, pilots, visual and radar navigation aids. This would provide yet one more feedback mechanism for a navigator during preparation.

4. Navaid Table

The *Type* attribute is a drop down list to categorize navigation aids (light, lighthouse, buoy, structure, building etc.) and assist in queries. The *Image File Name* attribute stores the JPEG filename. *Pub Description* includes information that is found in the various planning publications as a way of consolidating information into one easy access location. *Photo Avg.* stores the average value computed from the photographer's and other user's confidence entries.

5. Comments Table

This table captures comments made by users when viewing pictures already in the database. Units can make multiple comments, and photographs can have multiple comments made on them so both of these foreign keys reside in this table. The date is automatically entered when the user submits the comment.

6. Navaid Voyage Table

This table is required since voyages can contain multiple navaids, and a navaid can be associated with more than one voyage. Both foreign keys are contained within the table to relate the two objects.

E.   TANGO FOR ACCESS

In order to assist in developing applications to access the database through the GatorNet web site, we chose EveryWare Development Corporation's Tango product. This product provides a straightforward method to create basic query documents for accessing a relational database and formatting returned results. When searching for information from more than one table, the software allows the user to define joins. Creating applications to enter new records into a single table within the database is accomplished by using the *New Record Query Builder* function in the software. Expanding the functionality to enter data into related tables is accomplished by creating query documents for each table, and combining them by cutting and pasting the HTML code. SQL statements were used to increment primary keys and ensure foreign keys were entered into appropriate tables. Very little altering of the Tango-generated forms was necessary to obtain the figures shown throughout this chapter. Although not entirely point and click, Tango for Access greatly reduced the CGI coding requirements to achieve database interaction.

The Tango Server executes the requested query documents, performs the operations defined in the document, communicates with the database, and returns the results to the IIS server to be passed on to the user. A plug-in is provided for Microsoft's IIS to speed up the passing of information between the two servers. An application was required for each of the functions outlined in the previous Lessons Learned section of this chapter.

F.   WEB INTERFACE DEVELOPMENT

Front Page '97 was chosen for developing the GatorNet site. The primary reasons behind choosing this software package was availability and the compatibility with Microsoft IIS, Access 97, and the Windows NT operating system. The structures for several web pages within the prototype were created using wizards available within the software. No significant problems were encountered during development or publishing.

G. PROTOTYPE HARDWARE/SOFTWARE REQUIREMENTS AND COSTS

The prototype was developed on a 200MHZ Intel Pentium personal computer with 32Mb of RAM. Pictures were taken with a personal 35mm camera using an 80-210mm zoom lens. Images were scanned into the prototype using a HP ScanJet 4P scanner. No other special hardware was purchased or required. No special software or hardware was required so costs were truly kept to a minimum.

The following software was used to develop the prototype:

- Microsoft Office 97 (Word, Excel, Access)
- Corel Photo-Paint 5.0
- FrontPage 97
- Tango for Access
- Salsa Academic Edition for Students V 1.1
- Microsoft IIS
- Microsoft Internet Explorer and Netscape Communicator
- Windows NT 4.0

All software except Tango for Access was either already owned by the authors or available on the NPS personal computer used to develop the prototype. Tango's educational version cost under $150. As a benchmark for other rapid prototype developers, it is estimated that the suite of hardware and software used to develop and serve the prototype cost under $4,000. A full-scale implementation of the GatorNet concept would require much greater redundancy, speed, reliability and security and consequently be more expensive.

The site is served from the same personal computer used to develop the prototype. The computer is connected to a 10MBPS-Ethernet network at the Naval Postgraduate School and is accessible at http://pcjcm1.ece.nps.navy.mil/Gatorhome.htm.

V. FLEET IMPLEMENTATION OF A NEW NAVIGATION PLANNING SYSTEM AND ASSOCIATED INTEGRATION ISSUES

A high visibility and priority item in fleet navigation today is the program to finally transition from paper to digital nautical charts (DNC). The Electronic Chart Display and Information System (ECDIS) would accomplish this and be based on commercial standards that have extensions for military applications. Navigation sensors (such as GPS/DGPS/Inertial Gyros) will provide inputs to the system to allow positional display and assist in route planning and route monitoring. This system will significantly enhance safety through automatic grounding avoidance and audible alarms should the ship approach danger areas. In a brief dated 6 October 1997, RADM Tobin (N096, Oceanographer of the Navy) addressed these issues in an attempt to develop a cohesive transition plan and develop official Navy policy. Full fleet implementation would not be completed until fiscal year 2005 [Ref. 28].

The route planning available in this system would be enroute planning and assist in course, speed and time calculations. It is not the restricted water planning that has been the major thrust behind the GatorNet prototype. Commercial-off-the-shelf programs are available that assist in both types of planning. For example, the Cap'n is widely used by the fleet (Chapter II) and is ideal for enroute planning where Fairplay's CD-ROM contains a database of port information oriented toward commercial shipping information for the world's ports. Although ships can use these packages, they are not officially sanctioned for safety and liability reasons, and can place Commanding Officers in difficult positions should they rely on them to the neglect of other official sources.

By the year 2005, processor performance will have doubled fully five times if Moore's law holds constant. Optical devices will likely make data storage a non-issue. Low orbit satellite constellations will provide worldwide high bandwidth connectivity. What type of navigation systems could be built with these capabilities? The prospect of

being stationed on the last ship to receive yesterday's technology in the year 2005 is not very enticing.

A.   NAVIGATION PLANNING 2001—AN INFOTECH ODYSSEY

10 October 2001.   USS Carl Vinson (CVN-70) has just been upgraded with the Navy's latest C^{4}ISR systems as it conducts work-ups in preparation for extended deployment to the Mediterranean.   The crew is excited about it's upcoming port call in the newly opened port of Havana, Cuba.   A search of the Navigation-Archives CD-ROM has provided a good overview of port services, and photographs of the piers and tugs collected from overhead imagery and commercial ships.   The tide/current module produces chartlets with graphs showing predicted tides and currents for the date of the planned transit.   Unfortunately, the ship's navigator, LT Tobin Jr., knows the Commanding Officer will have many questions at the Navigation brief.   He anxiously sits down at his Pentium II 300 and connects to the SIPRNET to query the "Ports Application" on GCCS.   Because this is the first US ship to visit the port in over 40 years, he expects to find very little within the extensive lessons learned database. To his surprise, a Canadian combatant recently visited the port and has included a QuickTime video taken from their mast-mounted camera during the transit.   He requests the video and places a priority level of two on the video information packet.   Priority two corresponds to transmission over the Global Broadcast Service within the next six hours. For the meantime, he downloads the compressed audio debrief given by the Canadian Navigator on difficulties encountered during the transit as well as a description of the tugs, pilot, and berthing facilities.   Just as scheduled he receives the video.   The videographer has done a great job highlighting key navigation aids and features. The combination of the video and the audio debrief answer many of LT Tobin's questions. Knowing the system will have automatically queued and compressed pictures of the primary navigation aids, with another press of a button he downloads the pictures directly into the memory of the recently arrived electronic telescopic alidades.   The new

devices have split viewfinders (one side digital image, other side zoom-telescope) and are networked to the digital chart table to provide an electronic line of position and instantaneous fix at the push of a button. These fixes are automatically compared with DGPS to provide input to the ship's autopilot during restricted water transits.

Unfortunately, one of the navaid files is corrupt so LT Tobin seamlessly accesses the user database to contact the officer that submitted the file. After "whiteboard discussion" on a digital chart overlay of the harbor, the Canadian promises to resubmit the automatically archived file—all navigation, exercise, and lessons learned submissions are archived onto a personal removable Jazz drive that is assigned to the user (the Canadian in this instance). As users transfer between commands, they bring their drive with them and leave a copy at the command's electronic data repository. When individuals leave the service, the archives are maintained at the central repository for that particular service. Within a day the original file has been retransmitted, the previously requested burst download of satellite imagery for the port has been received, and the navigation team and Commanding Officer feel exceedingly well prepared to enter a port they've only virtually seen.

Everything described within this fictional scenario is technically possible today. The necessity for this capability might be a bit far-fetched to make a port call, but if the scenario is applied to a wartime amphibious operation or navigation of a minefield the argument against this capability is without substance.

B. WHAT IS NEXT FOR GATORNET?

The primary purpose behind a prototype is to ascertain user requirements. It should be created rapidly to speed up the system development life cycle (SDLC). Since there are no known initiatives currently in progress to develop a planning system like GatorNet, the goal has been to generate discussion and feedback for a well-defined requirements package. Additional goals of the prototype were to:

- Demonstrate new navigation-planning functionality that can be achieved with Information Technology and little programming effort (photographs, relational database, lessons learned)

- Change the way navigation planning is conducted, via active submission of lessons/pictures versus passively reading publications.

- Combine the numerous navigation sources into a "one-stop shop" of information.

- Introduce the concept of an online navigation forum.

The National Image and Mapping Agency is in the process of updating the 9600 baud NavInfoNet to a dynamic web site. If one designer of the new system accesses GatorNet and is influenced by the possibilities or implements one of the concepts, the prototype will have served its purpose.

C. INTEGRATION ISSUES FOR FLEET IMPLEMENTATION

Fielding a new system with the capabilities displayed in the prototype raises many integration issues. These issues have been organized into architectural, operational, personnel, cultural and economic categories.

1. Architecture Issues

Chapter III discussed many of the advantages and disadvantages of methods to distribute GatorNet information. With much of the information fairly static (port data), historical (lessons learned), or in a self-contained program format (course/speed/distance/ tme planning or tide/current calculations) the requirement for an "on-line" system is mitigated. Designing the system to be internal (hard drive resident programs with CD-ROM repository), improves the speed of the system and frees up valuable bandwidth for other applications. However, there are several functions that would benefit from a real time system including safety-related issues, retrieval of up-to-the-minute changes, or the

ability to contact a user for immediate feedback. Developing a hybrid system captures both of these advantages.

The architecture issues that follow are at the top of the integrated Fleet Commander in Chief's priority list [Ref. 24]. By the time a GatorNet system could be developed and introduced to the fleet, most of these issues will likely be solved.

a) Connectivity—Which pipe?

There are several initiatives to improve connectivity throughout the military. "C⁴I for the Warrior" is the Joint Staff's military information architecture designed to provide a fused, real time, true picture of the warrior's battlespace [Ref. 9:pp. 6-7]. As more systems are networked and increasingly more information becomes available, greater demand will be created. Convincing intelligence users, tactical watchstanders, and system administrators that the navigation planning evolution merits system time will be a difficult hurdle. If this can be accomplished, creating a GCCS application for navigation may be one alternative to meet this new demand.

Global Broadcast Service will provide an exponential increase over current SATCOM capacity. Capitalizing on commercially developed digital broadcast service (Direct TV) technology, users will request information (navigation) via conventional communications (e-mail) and receive a broadcast (port images/data) through a low cost receiver and small antenna [Ref. 12]. This smart push/warrior pull concept provides a viable conduit for implementing the GatorNet concept.

b) Bandwidth

How much bandwidth would a system with GatorNet's functionality require? A 28.8 KBPS modem that results in 3 KBPS throughput of data (due to communication overhead) has provided sufficient capability for prototype access. Bandwidth at sea will continue to be a resource highly sought after, as more systems are adapted to the information age. Compression techniques will aid in reducing the requirements. Initiatives such as Automated Digital Network System (ADNS) will allow

better sharing of bandwidth and provide a four-fold increase in throughput efficiency [Ref. 24]. Although a significant issue, it is already receiving considerable attention for much higher bandwidth applications such as video teleconferencing.

Server side bandwidth is critical to ensure proper expected response to the fleet. Based on the possibility of 500 users simultaneously requiring 3 KBPS each, a minimum 100 BaseT, FDDI, or OC-3 connection should be supplied to the network access point (NAP). This currently is in conformance with IT-21 standards.

c) *Storage Requirements*

By analyzing the rapid prototype, a projection can be made for the data storage size requirements of a full-scale implementation. The entire prototype site was just over 3 Mb, but contained additional information such as survey results, the thesis, as well as scanned images of charts. A fleet implementation could incorporate portions of vector format charts like those used within GCCS applications. The San Diego harbor is rich in navigation aids and contains more than would normally be available in the "average" port. Estimating that the average port requires 25 pictures of navigation aids, pier facilities, and port views and that each picture is 20 Kb results in 500Kb. Adding two chart segments at 50 Kb each and ten text-based web pages of information at 4 Kb brings the total port requirement to 640 Kb. An extremely robust set of extensive lessons learned could bring the total port size to 700 Kb. Using compression techniques well over 100 ports could be contained on a single CD-ROM. This approximates the number of ports the Navy regularly visits.

Theatres of operation could be created such that ships could download information prior to arrival. By packaging the data in compressed files, users could retrieve the information while pierside, or during "off-peak" times so as not to compete for limited assets. Flagships that have more bandwidth capability could download the files and distribute them to the remaining ships within the task group using Iomega ZIP or JAZZ disks. There are many alternatives to distributing and disseminating the

information. The important point to be gained from the prototype is that the file sizes can be minimized and standard 28.8 KBPS modems provide quick site interaction with minimal delays.

d) *Standardization*

The information required to provide a comprehensive navigation planning tool already exists. Digital Nautical Charts, navigation aid descriptions, lessons learned, and navigation publications reside in several independent repositories. The advantage of connecting these sources together into a coherent system (band-aid approach) would need to be weighed against creating a new relational or object oriented database that provides seamless integration of data. Whichever approach is taken, the system must be Defense Information Infrastructure Common Operating Environment (DII COE) compliant to allow wider dissemination [Ref. 13]. Using TCP/IP and the SIPRNET for the online portion of the system is one easy alternative. Considerable work addressing standardization has been accomplished with the Common Operational Modeling, Planning and Simulation Strategy (COMPASS) that establishes a set of standards for C^4I system and modeling and simulation system interaction. [Ref. 8].

Developers of a follow on application to GatorNet must balance the need for adequate detail within graphics while minimizing file size to reduce transfer times. A standard would need to be set for compression factors to ensure a minimum resolution was maintained. To ensure users understand the compression factors and to prevent misinterpretation of photographs, each image could either be annotated or have a corresponding database field to display the compression value when the picture is displayed. Defining these and other data standards and functionality is the first step in any system development.

e) *Reliability and Accountability*

Any system that will provide navigation planning information must have complete reliability. This explains the prolonged use of hardcopy chart and publications

within the Navy. If a ship must go into harms way, not having access to the necessary tools or information is unacceptable. This requirement calls for the minimum planning tools to be incorporated in a self-contained system—one that is not reliant on external communication sources beyond the navigator's control. Navigation information is currently updated through the mail on a weekly basis. If a ship is transiting OPAREAS in the Indian Ocean, quite often conventional mail can be delayed up to a month. Although a self-contained vessel, a naval ship cannot conduct its mission today in politically sensitive climates without access to Command and Control conduits. The line must be drawn somewhere between online reliability and internal systems. Designing a system to run on an IT-21 compliant personal computer that can quickly access a network for compressed program/safety updates should be the minimum approach. As a backup, the defense message system could always be used to send safety related information should the primary network be unavailable.

f) Security

The vast majority of navigation information is unclassified and widely available in open sources. Should the system be expanded to include exercise data or navigation contingency plans, greater security would be required. Commercial mariners could provide significant feedback to a navigation repository, but this adds the requirement of protecting the data from deliberate manipulation or denial of service attacks. Since the system has national security implications, keeping it within DoD is the best way of providing security. Using a protocol that supports encryption and a conduit that protects the information (SIPRNET) is the most feasible answer.

2. Operational Issues

Assuming a planning system is developed, how would information be gathered to increase the system's utility? Many of the mechanisms are currently in place. NIMA and the US Coast Guard already gather and update the primary navigation planning publications. Ships are tasked to submit port visit reports to update the Port Directory.

Many fleet commanders require lessons learned messages to be included in passdown folders. Collecting all this information into one location requires a centralized point of contact.

Adding shipboard procedures to collect meaningful photographs would only require prior planning. The manning is in place (Photographer's mates could be tasked or any individual not involved in the sea detail) and the equipment is available. With the improvement in digital cameras, uploading photographs would be straightforward. If pictures can't be taken during the transit, quartermasters could use the Captain's gig or motor whaleboat to document the harbor once in port.

Gathering data would also be simple if electronic debrief forms are available to capture information following each and every navigation evolution. These forms could be transmitted immediately if connectivity is available, or stored for later transmission or submission via postal service on disk. The biggest hurdle would be changing the mindset of the users. Once the advantages that can be gained are apparent, user support should follow. Training can be conducted within the fleet navigation schoolhouses, or could be accomplished through distance learning programs.

3. Personnel Issues

Maintaining an online site with vast quantities of data would require considerable support during the "build-up" phase. Once the majority of frequently visited port information was converted or documented, manning could be reduced to support incremental updates and requests. A small staff savvy in the selected system architecture and navigation issues should be able to manage the project at that point. A staff could be comprised of two senior quartermasters, a junior enlisted individual for graphics support, a system administrator and an arrangement for part-time maintenance. Owning a large portion of the data and having direct access to the infrastructure, NIMA seems the logical choice to manage such a system.

Naval decision-makers are fully onboard with Information Technology being used as a way to leverage our shrinking fighting forces. As world commitments persist and deployment turnaround schedules shrink, manning issues will surely plague the Navy. Much of the quartermaster's time is spent maintaining charts and publications, or laying tracks and calculating/graphing tides and currents. Adopting a navigation planning system that can reduce the manning requirements is certainly advantageous.

4. Cultural Issues

One of the most difficult issues surrounding this concept is that of culture. The Navy is steeped in traditions and one of the earliest is precise navigation on the high seas. The adversity to changing procedures and accepting Information Technology has diminished as captured by the fleet survey results. Many of the sailors and officers utilize computers and are familiar with their potential capability if applied to the navigation planning process. By the time a new planning system could be implemented, many remaining "resistors" will have retired

5. Economic Issues

In this day of declining budgets, hard decisions are being made over which systems will be funded, which ones will receive upgrades, and those that will be cut. Although a considerable up-front investment would be needed to design a new planning system, the savings that can be generated through reduced paper products, distribution costs, maintenance costs, and personnel should justify the expenditure over the years. The intangible cost associated with the negative publicity surrounding a ship's grounding or collision is hard to quantify. If a more comprehensive and current planning system prevents a single ship from running aground the system will have paid for itself.

Combining development efforts between the Coast Guard, National Ocean Service, and NIMA could reduce costs. Both will have an online presence through NAVCEN and NAVINFONET. Both the Coast Guard and NIMA have similar concerns over navigation safety. The key to keeping costs at a minimum is to take advantage of the

research and development for related systems building. As mentioned earlier, NIMA is in the process of revamping the NAVINFONET. GCCS has well defined standards for data format and transmission, and many applications are being added to the system.

D. FRAMEWORK FOR MANAGING PLANNED CHANGE

The primary deterrent against implementing planning concepts from GatorNet will likely come down to a choice in priorities. Ships have been navigating in and out of world ports, through narrow straits, and within swept channels of mine fields without having the coordinated suite of planning tools discussed in GatorNet for many years. GPS has significantly improved ship safety near shore, and DGPS is improving the accuracy to within meters. The systems can already be used as a viable backup to visual and radar procedures within restricted waters. With other navigation initiatives like DNC and ECDIS in the limelight, GatorNet could easily be deemed a low priority as programs compete for limited funds. Unfortunately, these arguments could be made for many years to come as new programs emerge. So how should the fleet users who are obviously ready and willing to change (Chapter II) influence navigation planners?

1. Is the Navy Ready to Change?

Until recently, an argument for changing navigation planning methods would have been difficult to support. The infrastructure for any sort of online system was not in place. Computers with CD-ROMS and certainly networks onboard ships were limited. But now that these issues are being resolved, the remaining obstacle is changing the way we present and distribute information that (for the most part) is already being collected.

Fleet users are increasingly computer savvy. They are aware of the leverage that can be gained through Information Technology. They thrive on technology and do not fear it like many previous decision-makers. The culture is ripe for change, but is the Naval Organization ready for change?

The Harvard Business School article *Leading Change* presents a conceptual formula that incorporates the critical dimensions of change that must be taken into consideration:

Amount of Change = (Dissatisfaction * Model * Process) > Cost of Change

Dissatisfaction is the source of energy that motivates change within the organization [Ref. 29]. Although many navigators may see the benefits of or prefer a new planning system, how many are actually dissatisfied with the current system? The fleet survey identified quartermasters that are frustrated with the need to correct publications and charts instead of having digital charts with computer updates. There are navigators that haven't used the current lessons learned system or find it difficult to access. But these issues miss the central themes behind GatorNet. To raise dissatisfaction, users must first see what they are missing. The GatorNet prototype should raise awareness and hopefully increase dissatisfaction.

There are many models used to evaluate an organization's fundamental aspects—structure, processes, environment, people, strategies, tasks, and culture to name a few aspects. Once the relationships between these aspects are understood, it is easier to determine which lever should be pulled to initiate change. A future model of navigation planning is needed as a vision that would help galvanize the change effort. DoD is adept at creating visionary documents and programs for overarching efforts (such as JV2010, Copernicus, and C4I for the Warrior). The program managers in charge of navigation planning need to create a realistic visionary model that the organization can strive toward.

A roadmap must be defined to aid in the change process. Users need to be brought into this process not only to obtain accurate requirements (fleet survey/evaluation of GatorNet), but also to buy into the change process. From the survey results, the majority of users appear to have "bought in"; now a change process needs to be defined.

The equation states the product of dissatisfaction, model and process must be greater than the cost of change to achieve success. The costs associated with changing navigation planning are more than monetary. There is still a small cadre of "old-timers"

that believe in traditional navigation. NTIC lessons learned stakeholders may be threatened by a new system—the survey suggests the system has failed regarding navigation. Users of limited bandwidth would see another system competing for limited resources. The time required to develop and maintain this system would detract from others. The additional time required for users to assist in populating databases with quality lessons learned, photographs and voyage feedback would add to an existing workload.

The amount of change likely to take place given this equation does not seem promising. However, one advantage of military decision-makers is the ability to order change and know it will be accepted. Given a properly designed system, once users experience the vast information stores that can easily be placed at their fingertips they will wish they had initiated change ten years earlier.

2. When to Implement Change?

The Harvard Business School Note: "The Challenge of Change" [Ref. 30] indicates the process of change "may be easier when the organization is in crisis: the situation is clear to all, survival is on the line; everyone recognizes that the way things have been done won't work anymore." There is no navigation-planning crisis present that will force the Navy to change. No crisis was needed to initiate the transitional change that has already begun. Navigation publications are now being distributed on CD-ROMS. A formalized lessons learned system now exists where one did not in 1991. All admirals and most commands now have e-mail addresses. Ships are being networked. IT-21 is providing the equipment necessary to implement a hard-drive resident database program, CD-ROM archive, or Windows NT client-server planning tool. Many initiatives are in place to increase connectivity at sea. With all these changes already taking place, it is time to redefine how we conduct navigation planning and harness these advances toward a coordinated navigation planning system.

VI.   CONCLUSIONS

A.   SUMMARY OF FINDINGS

1.   Project Accomplishments

Accomplishments of the thesis project are summarized as follows:

a)   Research Achievements

- A review of existing navigation planning procedures was conducted and documented in Chapter I.

- A study of existing fleet navigation information sources and initiatives was conducted and results were documented in Chapter I.

- An analysis of how to improve the existing navigation planning process was conducted and results were documented in Chapters II and V.

- A study of migration alternatives was conducted and documented in Chapter III.

b)   Rapid Prototype

A conceptual Navigation Planning Information Architecture was proven via the GatorNet rapid prototype navigation-planning tool described in Chapter IV. The benefits of client-server information technology and potential benefits for the fleet have been shown. A relational database of navigation lessons learned and a graphical Web-based user interface were developed in the prototype to permit interaction with the database. The prototype "GatorNet" is on-line and is available for viewing (as of the publishing of this thesis) at: http://pcjcm1.ece.nps.navy.mil/Gatorhome.htm.

c)   User Requirements Document

A fleet survey was developed and distributed to generate feedback, which has been consolidated into a requirements document. These requirements were documented in Chapter II and Appendix E.

2. Lessons Learned

a) *Positive Lesson Learned*

A positive lesson from the project was that a full year was allowed to conduct the research necessary to develop the prototype. This year was actually needed in order to involve the navigation "users" in the process as mentioned in Chapter V (section D.1). This capture of positive lessons is in keeping with the Chapter IV (section A.2) recommendation to capture positive lessons along with negative lessons from the fleet.

b) *Netscape Enterprise Server Installation*

An unsuccessful attempt was made to use non-Microsoft server software: Netscape Enterprise Server. This may have been due to the proprietary nature of commercial software design and the fact that all other software in the prototype suite was either a Microsoft product or a Microsoft compatible product. Once a Microsoft server product was used (Internet Information Server) there were no more compatibility problems encountered.

c) *Prototype Development Timeline*

The original project milestone date to complete prototype development was not met. Three more months were needed to complete and publish the prototype, because ample time was not allowed to learn the new software. If the original date had been achieved, more effort could have been expended to continue to keep the users involved, so that additional feedback could be incorporated into future prototype revisions.

B. PROJECT CONCLUSIONS

1. Smart Ship Navigation Initiatives: A Good First Step

The SMART SHIP project described in Chapter I was initiated by the Naval Research Advisory Committee and the Chief of Naval Operations, and the operational platform chosen was the USS YORKTOWN (CG-48). The project has been considered by many to be a major success, mainly because commercial-off-the-shelf (COTS) technology was added to the existing ship's systems to achieve new efficiencies and help to reduce manning by 17% [Ref. 31]. According to a senior Navy official, "YORKTOWN was able to cut billets off the ship by introducing technology and by letting the crew come up with better ways of doing things." [Ref. 32] The same official stated that the efficiencies developed in YORKTOWN were gained by implementing "out-of-the-box ideas" generated on that ship. The ship found its new navigation efficiencies by using Digital Nautical Charting, the NAVSSI system, Sperry's Voyage Management System, and by reducing their chart inventory of two sets of up-to-date paper charts to one set. By eliminating their holdings of redundant copies of paper charts, they reduced the weekly chart maintenance hours by 50% [Ref. 33].

2. Fleet Navigators are Ready for Automated Navigation Planning

The authors were extremely encouraged to learn that the U. S. Navy navigation "users" support for automating manual navigation planning tasks is nearly unanimous (Appendix E). The findings from the survey show that it is widely recognized that opportunities exist to gain efficiency by automating manual navigation planning tasks, such as data collection and processing. However, maintaining one complete set of paper charts onboard ship, as is the practice aboard YORKTOWN, may be prudent for use as a "Battle Backup" method of navigating without reliance on communication satellites or computers, which may become casualties in combat.

3.   The Coast Guard is Ahead of the Navy in Digitizing Navigation

Significant navigation advances have taken place onboard U. S. Coast Guard vessels, as evidenced by the USCGC JUNIPER's use of new navigation technology. Having been commissioned in early 1996, JUNIPER was called on to coordinate early efforts to recover aircraft wreckage from the TWA Flight 800 disaster. JUNIPER's early ocean floor wreckage survey was conducted using DGPS and new voyage management software to successfully map ocean floor wreckage and to autopilot the ship to maintain a continuous position on top of wreckage. To summarize this process:

> The Juniper uses a GPS receiver as part of a shipboard fiber-optic local-area network (LAN). The LAN runs two key PC-based software packages: the Electronic Charting System, a computerized nautical chart developed by Offshore Systems Ltd.; and the Dynamic Routing System, a navigation software package created by Nautronix. By combining these programs with the positioning information, the ship has the capability to drive itself. The computer system enabled the JUNIPER to hold in place automatically by monitoring the GPS information and engaging thrusters or propellers…the crew could run on autopilot with precision by laying out a course on the electronic chart and then feeding it into the Dynamic Routing System. The JUNIPER tapped into the Differential GPS System (DGPS) which fine-tuned…the position to an accuracy of two meters [Ref. 34].

This superior new technology has not yet been installed aboard Navy ships, but the new systems (NAVSSI and VMS) and initiatives proven in YORKTOWN are a much-needed step in the right direction. JUNIPER's technology demonstrates the feasibility of allowing computer systems to autopilot ships into port. It is conceivable that in the future, ship visual navigation teams may serve only a supervisory role.

A primary mission of the U. S. Coast Guard is to promote the safety of marine navigation. The Coast Guard does a thorough job of centrally managing navigation issues such as notices to mariners through the centrally managed NAVCEN WWW site. NIMA's Marine Navigation WWW or SIPRNET page could be improved along these lines, by changing the current static design to an active one, which would allow continuous updates to navigation data.

4. The Network Centric Warfare Concept Should Include Navigation Planning

The United States Navy's leadership has embarked on an ambitious plan to leverage computer network technology in such a way that all administrative and even tactical functions are driven to the desktop computer; the IT-21 vision. Network Centric Warfare is a related concept of VADM Cebrowski, the Deputy Chief of Naval Operations for communications and computer matters. VADM Cebrowski's concept,

> Holds enormous potential for the surface navy. If you consider an Internet web page analogy, Network Centric Warfare will establish a wide area network of reliable satellite connectivity. In the past...it was only within the (ship's) lifelines that you were able to pull together disparate data and make sense out of it in a given situation. Now the data for a particular mission is available to be pulled down...from the Internet. This will allow us to...maximize the combat capabilities of all our surface platforms. Network Centric Warfare will accelerate the information processing function and then distribute it to the total force. Ships in large numbers will then have the connectivity and tools available to...conduct mission planning, without having to rely on the large decks (such as aircraft carriers) [Ref. 35].

In addition to the Network Centric Warfare concept, a "System of Systems" approach to manage heterogeneous navigation data and applications is also needed [Ref. 36]. The GCCS system is a perfect example of such a combination of systems. Numerous joint navigation applications and data sources could therefore be combined into a single powerful tool, thereby allowing true "one stop shopping" when it is time to plan a navigation evolution.

5. There is a Definite Trend Within the Navy to Move Toward Digital Navigation

The new attack submarine (NSSN) is being built with no chart stowage onboard. [Ref. 28] This is a significant indication that the U. S. Navy is committed to doing away with paper charts and eventually migrating to a fully digital method of navigation:

> The technological revolution has additionally impacted naval operations with respect to GGI&S (Global Geospatial Information and Services). The

Navy, in concert with NIMA (National Imagery and Mapping Agency), and national and international organizations, is moving to utilize a vector database keyed to positional information from GPS, to provide electronic navigational charting. The present goal is to utilize the Digital Nautical Chart (DNC) (TM) with worldwide production by 1999. ...In a parallel development, the New Attack Submarine (NSSN) is being designed without chart lockers and will fully employ digital charts and electronic navigation. Fully integrated navigation systems are clearly a long-term goal, but in the short term, we are encouraging the use of stand-alone electronic charting systems that are ready now to dramatically improve situational awareness for our bridge watch teams [Ref. 37].

In addition to the significance of a new vessel without paper charts, there is another important acknowledgement in the previous quote: that a fully integrated navigation system is needed. Navigation *planning* functions must be included in any new integrated system.

6.   Navigation Tradition and Culture Paradigms Need to Shift

An uncomfortable tradition exists in the Navy regarding a ship grounding: A ship's Captain and Navigator are guilty until proven innocent. Any such incident almost always results in the end of the careers of any officers involved with such a misfortune. This fearful tradition will make any changes to the paper method of navigation a tough paradigm to crack. Fortunately, Navy attitudes toward the culture of computer network technology are shifting, thanks to initiatives like IT-21 and others:

As the information age in the Navy is poised to enter the (next) phase of development, we must go beyond simply improving our tools, and instead leverage those tools to fundamentally change our processes. This is the philosophy behind IT-21. It is a paradigm shift in how we create, manage, and retrieve information [Ref. 38].

In 1997, YORKTOWN navigated to a precision anchorage in the Chesapeake Bay using the autopilot feature of the Sperry Marine Voyage Management System. When shifting to computer ship control, the ship's officers give the command to the bridge console operator: "Shift control (of the ship) to the VMS!" The Naval Research and

Advisory Committee (NRAC) panel reported that the major obstacles to (SMART SHIP) reduced manning and decreased life cycle costs aboard Navy ships were culture and tradition rather than the lack of proven technology and know-how. Further, that expenditures on available technology and implementation of policy and procedure changes make manpower reductions achievable [Ref. 31].

C.   RECOMMENDATIONS

1.   Continue Refinement of GatorNet Prototype

The GatorNet prototype does not yet contain enough hard data for fleet implementation. Continued refinement of the system and widespread exposure to the fleet will help to further refine user requirements. With a larger database repository (e.g. all West coast ports photographed and substantially more lessons learned), GatorNet may eventually be added to a SMART SHIP or SMART GATOR platform as an experimental system in the very near future.

2.   Migrate GatorNet to the SIPRNET

Use the SIPRNET as the C4ISR conduit and complete development of the GatorNet prototype into a beefed-up GCCS "Ports" application. Although the majority of navigation information is unclassified, any data or planning system is extremely vulnerable to Information Warfare. Because the security of this information is of vital importance to ship safety, it should be afforded a high level of protection such as that provided by the SIPRNET and GCCS.

This migration should be managed to coincide with the NIMA initiative to digitize all navigation products for placement on the SIPRNET by the end of 1998.

3.   Transition the NTIC NLLS to the SIPRNET Through an On-Line, Interactive Client-Server Database Back-end

As shown in Chapter II (Table 2-8), very few fleet users are using the current lessons learned system. An on-line system would save the considerable distribution costs

associated with the current method of quarterly CD ROM updates. Transitioning the NTIC NLLS to a secure system such as the SIPRNET would avail fleet users and other interested joint military planners of the latest lessons learned. Due to the ease of access of an on-line system, more lessons can be captured, including positive lessons along with the negative ones. In addition, capturing quantitative lesson data (along with qualitative information) would allow statistical analysis (e.g. rating averages) and a revised lesson questionnaire format could help to facilitate this.

4. Designate a Single Agency to Manage all Migration Issues Associated with Automating Navigation

During research for the thesis, it became obvious to the authors that there are several U. S. Government initiatives underway to improve maritime navigation. Some of these initiatives were described in Chapter I. This thesis has addressed an area believed to be wholly overlooked, which is the issue of migrating manual *navigation planning* tasks to automated methods. There exists a glaring need for our government and military to designate a single responsible office to coordinate and harmonize the numerous fragmented efforts currently underway. An annual national professional navigation conference or symposium would also greatly benefit all interested parties, such as the United States Navy, the United States Coast Guard, the National Imagery and Mapping Agency, the National Ocean Service, and the Maritime Administration.

D. SUGGESTED AREAS FOR FURTHER STUDY

1. Conduct a Study of All of the Latest Navigation Voyage Management Software

The Full Utility Navigation Demonstration (FUND) software initial version was just released in December, 1997 [Ref. 20]. The Defense Mapping Agency Mapping, Charting, and Geodesy Utility Software Environment (DMAMUSE) program is another ECDIS software title which should be reviewed in order to explore the feasibility of navigation planning product compatibility. Can these software packages, which were

primarily designed to manage electronic charts, also be leveraged to accept the full range of heterogeneous digital navigation planning products?

2.   Conduct a Review of all Relevant Databases that Contain Navigation Information

A review of navigation data sources should be conducted. This will most likely require extensive travel and an appropriate security clearance, as some data is resident in classified databases. The National Imagery and Mapping Agency headquarters in Northern Virginia is a good place to start this study. In addition to surveying what databases (both commercial and military) are relevant to navigation planning, methods of integrating and consolidating the disparate data should be explored.

3.   Investigate the Feasibility of Marrying Littoral Digital Overhead Imagery with Navigation-Planning

There exists in the fleet a tremendous need for easy access to near-shore and beach overhead imagery to help support key decision-makers in the planning for amphibious and special operations. An appropriate tool needs to be developed to properly identify and label such imagery, which has navigational value. For example, littoral imagery might show the presence of heavy offshore kelp, which could foul the screws (propellers) of certain displacement landing craft and cause decision-makers to opt to use air cushion landing craft. Similarly, littoral imagery might also show the presence of beach obstacles (either natural or man-made) or an unknown offshore sandbar that might make a particular amphibious or expeditionary operation infeasible or unacceptably risky. In many cases, existing imagery could be used rather than brand-new products. If necessary, national assets could be tasked in a crisis to develop this navigation-specific imagery, which could be pushed to planners through robust intelligence networks already in place in the fleet. A method needs to be developed to screen all near-shore imagery and label or tag those images which have navigational value, so that they can be "pulled" by warfighters to aid in time-sensitive operational decisions.

APPENDIX A. LIST OF NAVIGATION PLANNING PUBLICATIONS AND PRODUCTS

This listing shows the majority of the hard-copy publications, charts, messages, and other products which are used in the manual navigation planning process.

- COMNAVSURFLANT/COMNAVSURFPAC/AIRPAC/AIRLANTINST 3530.4: Surface Ship Navigation Department Organization and Regulations Manual

- Pub. 9, American Practical Navigator

- Nautical Charts

- NIMA Fleet Guides

- Port Directory

- Pub. 150, World Port Index

- Pub. 151, Distance Between Ports

- Pub. 152, Sailing Directions (Planning Guides)

- Pub. 153, Sailing Directions (Enroute)

- Notice to Mariners (NIMA/NOS/U.S. Coast Guard)

- Local Notice to Mariners (U.S. Coast Guard)

- Light List (U.S. Coast Guard)

- List of Lights (NIMA)

- Navigation Rules (COMDTINST M16672.2C)

- U.S. Coast Pilots

- Tide and Current Tables

- Pub. 606, Guide to Marine Observation and Reporting

- Summary of Chart and Publication Corrections

- HYDROPAC/LANT Safety Messages

- Nautical Almanac

- Typhoon/Hurricane Havens Handbook

APPENDIX B. FLEET NAVIGATION SURVEY

Note: Although you may not currently have access to the World Wide Web, please assume you have it or will have it in the near future when responding to these questions. Please feel free to use additional sheets for your responses, if necessary. Also, please indicate "N/A" for questions which do not apply to your situation.

1. Please provide the following information:

    Rank_____ Title_____ Time in billet (mos)____ # QMs on board_____
    Command (Staff or ship platform (i.e. DESRON, CV, etc.)_____
    Current command status (ashore, deployed, maint. availability, etc.)_____

2. The new National Imagery and Mapping Agency (NIMA) is currently working on providing digitized charts and publications to the fleet user. Are there any requirements that you have which you would like to be included in NIMA's efforts?

3. Would you prefer to keep the current publication system for navigation planning, or would you prefer to have a new interactive "on-line" system developed?

4. What type of Navigation Lessons Learned "library" (if any) does your command maintain now?

5. What configuration would you prefer for a consolidated location or "library" of electronic Navigation information?

Note: For question (6), please choose the degree of importance of each type of data from <u>one</u> of the following:

    1. Not Important 2. Somewhat Important 3. No Opinion/Neutral 4. Important 5. Essential

6. If the following navigation related information sources were accessible in a single location, how important would they be to you? (<u>Please circle your choices</u>)

    1 2 3 4 5 Pictures of aids to navigation (range markers, towers, tanks, lights, etc.)
    1 2 3 4 5 Lessons Learned from other commands who have "gone before"
    1 2 3 4 5 Digitized navigation publications (Sailing Directions, Coast Pilot,
                 List of Lights/Light List, Fleet Guides, etc.)
    1 2 3 4 5 Digitized charts and display
    1 2 3 4 5 Safety messages (HYDROPAC/LANT, NOTAMS)
    1 2 3 4 5 Overhead littoral imagery of navigation value
    1 2 3 4 5 Amphibious planning data (hydro surveys, assault plans, etc.)
    1 2 3 4 5 Historical exercise data (conops, clearance requirements, lead times, etc.)
    1 2 3 4 5 Meteorological data (tide/current predictions, prevailing conditions, etc.)
    1 2 3 4 5 Port data (pilotage, tugs, berth and port facilities, etc.)

7. What navigation data or information sources would you add to a single, central navigation "library?"

8. I have used the Navy Tactical Information Compendium (NTIC) series library and Navy Lessons Learned System as follows (please check all choices which apply):

Purpose	Frequency of Use
◊ Exercise	◊ Never
◊ Transit	◊ Seldom (i.e. once/mo. or less)
◊ Port Visit	◊ Regularly (i.e. once/wk. or more)
◊ Amphib Ops	◊ Other_____
◊ Other_____	

9. On average, my command spends the following amount of time (in manhours) every week maintaining and correcting:

Item	Time spent maintaining
◊ HYDROPAC/LANT and Notam files	_____
◊ Navigation Publications	_____
◊ Charts	_____
◊ Other _____	_____

10. In previous planning, what missing information did you need from other commands who had completed the same event?

11. I have used the following systems for navigation planning (check all that apply):

◊ GCCS   ◊ WWW   ◊ JDISS   ◊ Commercial Software   ◊ Other_____
                                                    Title:_____

12. If you have used a system from question (11) for navigation planning, for what purpose did you use it?

13. In order to improve fleet feedback and to capture Navigation Lessons Learned, an improved method needs to be developed. Quantitative data (i.e. rating of tugs and pilot, navigation aid usefulness, etc.) as well as qualitative comments need to be collected. Please provide your thoughts on how this could best be accomplished.

14. We are looking for ideas to improve fleet navigation planning, and we welcome your feedback. Please provide any comments or suggestions in the space below, and feel free to attach additional sheets if necessary. Thank you for your cooperation.

APPENDIX C. SURVEY DEMOGRAPHICS

The following tables provide statistics on the number of respondents and their demographic makeup.

General Information		Surveys Received	Population Size	Percentage of Pop.
Number of Total Respondents:		238		
Number of Total Commands:		159	396	40.2%
Number of Ships:		130	333	39.0%
Number of Staffs:		29	63	46.0%
Lost Surveys		1		
Misc/Unresolved		1		
Ships by Type:	CV/CVN	6	12	50.0%
	CG/CGN	12	27	44.4%
	DD/DDG	21	56	37.5%
	FFG	16	42	38.1%
	Total CRUDES	49	125	39.2%
	SSN	24	68	35.3%
	SSBN	6	18	33.3%
	Total Subs	30	86	34.9%
	LCC	1	2	50.0%
	LHA	3	5	60.0%
	LHD	0	5	0.0%
	LPD	2	11	18.2%
	LPH	1	1	100.0%
	LSD	5	16	31.3%
	LST	1	2	50.0%
	Total Amphibs	13	42	31.0%
	MCS	0	1	0.0%
	MCM	8	14	57.1%
	MHC	2	9	22.2%
	Total Mine Warfare	10	24	41.7%

	PC	5	13	38.5%
	AE	2	2	100.0%
	AO	2	5	40.0%
	T-AFS/AO/ATF	4	4	100.0%
	AOE	3	7	42.9%
	Total Logistics	11	18	61.1%
	AS	3	4	75.0%
	AGF	1	2	50.0%
	AGSS	1	1	100.0%
	ARS	2	4	50.0%
	Total Aux Ships	7	11	63.6%
	Total	131	331	39.6%
Staffs By Type	Fleet	2	5	40.0%
	CARGRU	4	8	50.0%
	CRUDESGRU	2	6	33.3%
	DESRON	7	17	41.2%
	SUBGRU	5	5	100.0%
	SUBRON	3	10	30.0%
	PHIBRGRU	0	3	0.0%
	PHIBRON	4	9	44.4%
	Total	27	63	42.9%

Months in Job		Percent	**Rank**	
>36	26	10.9%	>E-7	37
12 to 36	103	43.3%	<=E-6	44
< 12	97	40.8%	Second Officer	3
Not Specified	12	5.0%	O-1 - O-3	113
Total	238		O-4	28
			O5-O-6	10
Job Title			Unknown	3
Navigators	103		Total	238
Asst. Navig.	30 (Duplicates w/ Nav LCPOs)			
Staff Nav	6			
CO	2			
CSO	4			
XO	13			
Operations Officer	31			

OPS Jobs	14 (Asst.Ops, CICO, Amphib Ops, Staff Ops, Schedulers)
NAV LPO/LCPO	20
OPS LPO/LCPO	14
QMs	7
Total	244

Respondents by Job
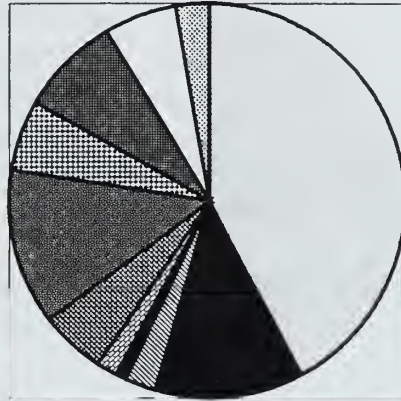
- □ Navigators
- ■ Asst. Navig.
- ▨ Staff Nav
- ■ CO
- ▨ CSO
- ▨ XO
- ▨ Operations Officer
- ▦ OPS Jobs
- ▨ NAV LPO/LCPO
- □ OPS LPO/LCPO
- ▨ QMs

APPENDIX D. STATISTICAL CALCULATIONS FOR POPULATION MEAN CONFIDENCE INTERVALS

The following calculations show values used to compute the confidence intervals depending on sample and population size. With only 13 respondents, the student's "t" distribution was required for Amphibious results. The number of navigators responding was large enough to use standard normal distribution computations.

The symbols used in the tables are:

N= Observations
0 = Sample mean
Φ = Population mean .
S_x = Sample standard deviation
Z alpha/2 = Standard normal random variable
t_{n-1} = Random Variable from Student's t distribution with (n-1) degrees of freedom

Formula for calculating the Confidence interval for the Mean of a Normal Population, small sample size

$$0 - (t_{n-1}) \cdot S_x / SQRT(N) < \Phi < 0 + (t_{n-1}) \cdot S_x / SQRT(N)$$

	Amphibious		
N	13	13	13
0	4.29	4.29	4.29
S_x	0.85	0.85	0.85
t_{n-1}	95%	90%	80%
Table value	2.179	1.782	1.356
Pop Mean Range			
Low value	3.78	3.87	3.97
High value	4.80	4.71	4.61

Confidence Interval for the Population Mean: Large Sample Sizes

Note: When the sample size is large, the sample standard deviation will be a sufficiently good estimator of the population standard deviation to allow us to use the former in place of the latter without affecting the probability content of the intervals.

$$0 - (Z\ alpha/2)*S_x/ SQRT(N) < \Phi < 0 + (Z\ alpha/2)*S_x/ SQRT(N)$$

	Navigators		
N	103	103	103
0	4.19	4.19	4.19
Sx	0.71	0.71	0.71
Z alpha/2	99%	95%	90%
Table Value	2.57	1.96	1.65
Low Value	4.01	4.05	4.07
High Value	4.37	4.33	4.31

	All Responses		
N	238	238	238
X Bar	4.1	4.1	4.1
Sx	0.94	0.94	0.94
Z alpha/2	99%	95%	90%
Table Value	2.57	1.96	1.65
Low Value	3.94	3.98	4.00
High Value	4.26	4.22	4.20

APPENDIX E. NAVIGATION SURVEY RESULTS

These are narrative responses to survey questions 2, 3, 5, 7, 10, and 14, received from July to October, 1997. Not all responses from all commands who participated in the survey are included here. Comments from commands who provided thorough responses which are useful to navigation planning are listed. Responses are paraphrased, and in some cases are directly quoted as indicated.

USS SALVOR (ARS-52), Navigator
- Need a Waypoint to Waypoint (voyage planning) calculator.
- Good argument for "single source" Nav Repository in response #3
- Include "Typhoon Havens"

USS PRINCETON (CG-59), Navigator
- Strong argument for Pictures of Navaids!
- Good argument for CD-Rom technology (updatable?)
- Make digital charts vector charts (vice Raster) which are easily updated with commercial software.

FFG, Navigator
- "Put AAR File from DC into a database." (FICM Port Visit Report)

USS SIMPSON (FFG-56), Ops
- "Make SURFLANT port-visit reports (FICM Format) available in a database!"
- Include access to NGFS, Bottom Contour and Jog-Air Charts

COMCARGRU TWO, Surface Ops Officer
- Query port database by: 1) name, 2) lat/lon
- Port-to-Port transit and time/distance figures

USS TAYLOR (FFG-50), XO
- "Investigate commercial nav software the Coast Guard uses."
- Include Traffic Patterns
- Condition of piers and camel/fender capability
- Foreign Port Tides

COMSUBGRU TWENTY, Asst. Ops Officer
- Include classified NOTAMs
- Changes in Shoaling

DESRON TWO, Navigator

- Distances between ports
- Terrestrial (road/area) Maps of Arabian Gulf Ports to help determine usable Navaids
- Pictures of Harbor

USS KITTY HAWK (CV-63), Chief Quartermaster
- "It would be great for all afloat units to have access to WWW to be able to access NAV info any time."
- "GPS Interfaceable"
- Accepts NIMA's digital charts"
- "Depths at berths"

USS DEXTROUS (MCM-13), XO/Navigator
- Beach Topography
- Bottom contours/type/gradient
- Display ship size to scale
- "On-line would save space on cramped MCM"

USS ENTERPRISE (CVN-65), Navigator
- ECDIS Planning Tool?
- Accurate Port/Anchorage charts for frequently visited foreign ports.

USS L. MENDEL RIVERS (SSN-686), Nav/Ops
- "Include foreign charts" (especially for ports)

USS TORTUGA (LSD-46), Navigator
- Standard Approach Tracks
- Lights and Navaids with Pictures and Descriptions
- Plot tracks, anchorages, boat lanes
- Ability to calculate celestial data...movreps...trip planning
- Coverage of "Hard to Reach" Areas

USS CROMMELIN (FFG-37), Navigator
- Include OPAREAS (as overlays)
- Pier data, tug availability, BTB channel
- Recommended pilot pick-up points

USS O'BRIEN (DDG-975), Leading QM
- Need Nav Dept. Hardware support! (PC, CD-ROM, modem, dedicated phone line, etc.)

USS PONCE (LPD-15), Navigator
- "Bulletin Board" for on-line system

LHA (Westcoast), Navigator
- Include "British Recommended Route Book"

USS COLUMBUS (SSN-762), Navigator
- Visual LOPs into auto-updated position
- Ability to "personalize" graphical display....Navaids highlighted, Tug RDVU points, etc.

USS COMSTOCK (LSD-45), Navigator
- Develop a Cross-Reference System to enable ordering Foreign Charts
- "Make it like JICPAC Home Page"

USS SOUTH CAROLINA, Navigator
- Use MOVREP for PVISIT Feedback
- Disk/CD updates for non-Internet Commands

USS SACRAMENTO (AOE-1), Asst. Navigator
- NAVTREK
- Digital Chart Display with GPS Interface
- (DBMS) Query by Port

USS KLAKRING (FFG-42), Navigator
- Include "Safe Speed" along port transit legs
- Pilot Pickup Points

CRUDESGRU TWO, Navigator
- Include Pictures of Navaids!
- "Hot" Areas

SUBRON ONE, Ops Officer
- 3-D Charts for subs!

COMCARGRU FIVE, Sub Ops
- Vector Charts vice Raster
- E-Series Sub Charts digitized by NIMA
- GPS-ESGN
- LAN accessible display
- Select/Deselectable information; design Web Site with "filtering!"

USS CHIEF (MCM-14), Navigation Officer
- MCM's: not enough phone lines for NAVINFONET dump!
- Add to PCO/PXO pipeline training on electronic NAV technology.

COMDESRON FIVE, Navigator
- WRN-6 Interface
- Pierside Depths
- Feedback form for ideas
- Training/Documentation for new system

USS GUNGSTON HALL (LSD-44), Navigator and Ops Officer
- Forego Celestial Nav! (Nav)
- Include Husbanding Agent e-mail address (Ops)

CLF (AO), Navigator
- Consolidate Nav transit/port visit feedback with MOVREP.

USS MIAMI (SSN-755), Navigator
- Include bottom contour charts
- Traffic Density for Port Visits

USS CLARK (FFG-11), LPO Nav. Dept.
- "Storm Tracking" function

USS SENTRY (MCM-3), ANAV (QM1(SW) Powell)
- Great tool: Integrating GPS and Cap'n onboard.

USS AUSTIN (LPD-4), ANAV
- QMC memo to CNSL has documented need to upgrade Nav planning technology

USS LOUISVILLE (SSN-724), Navigator
- Produce "Chartlets" of OPAREAS (Cargru 7)
- "JMCIS compatible"

CVN, ANAV
- Downloaded off of NIPRNET/SIPRNET
- Include Port visit reports
- Include Pictures of Navaids

USS INDEPENDENCE (CV-62), LCPO
- Include on Web site: "Advance/Transfer tables for ship class"

USS ARKANSAS (CGN-41), Navigator
- Highlightable shoal water based on ship's draft/input
- Display current vectors real-time (direction and velocity)
- Database of historical OTSR divert data
- Generate Nav Aids expected to see based on intended track
- Civilian/NOAA POC for improving NAV

USS MONTPELIER (SSN-765), CO
- Internet unavailable while submerged!
- Digital charts and pubs would greatly ease sub stowage problem!

AE, Navigator (West Coast)
- Add Harbor "Common Approach" tracks

CARGRU FOUR, Staff QM
- Point and Click to get blown up Picture of Navaid!
- Digitized charts/pubs would bring postage/shipping savings as a tangible benefit

COMDESRON FIFTEEN, OSC
- "Software to simplify ordering charts" (push/pull technology)
- Time-Distance planning
- "Fuel Burn Predictions" by ship class

USS PHILIPPINE SEA (CG-58), Navigator
- Query (i.e., NavAreas, Hydrolants by Chart #)
- Pilot pick-up pts, anchorages
- Make feedback form a TYCOM directive

USS STOUT (DDG-55), Navigator
- SURFLANT Database (ports) available upon request via Code: CNSL N333

USS PETERSON (DD-969), Navigator
- Want "Pier" info: Depth at berth, pier specs, etc.!

COMDESRON TWENTY SIX, Chief of Staff
- "Danger Contours"
- Bearings based on ship class
- Status of lights/navaids: "Operational, light out..."

PC, CO
- Need system compatible with PC CZ/VMS system

USS AUBREY FITCH (FFG-34), LPO
- Be able to change scale of chart (zoom in/out)
- (NIMA Feedback) Need better scale charts for Panama Canal, etc.

USS ROBERT G. BRADLEY (FFG-49), Navigator
- "Standardize the names of Navaids, so that all USN ships called the available Navaids by the same name."
- "Found that many of the Navaids we thought would work didn't."

USS TREPANG (SSN-674), Ops.
- Put Navaid ID on charts so periscope operator can quickly and correctly identify Navaids.

USS JAMES K. POLK (SSN-645), Navigator
- See SUBPAC/LANT Inst. 5400 (Nav Operations Dept.)
- CINCLANTFLEET and CINCUSNAVEUR maintain vast list of port visit reports
- Include DOD 2005.1M Maritime Claims Manual for pub digitization.

USS CIMARRON (AO-177), Navigator
- Digital Chart system should have onboard) "printing capability for portable use like for Boat Officers."

USS FIFE (DD-991), CO
- Revive old USN "Mishaps at Sea" database/pub.

USS HUE CITY (CG-66), Navigator
- Anchorage Positions and bearings (visual aids).

USS ZEPHYR (PC-8), Ops.
- "We digitize our own charts"
- Compatible with Sperry IBS System?

USS TICONDEROGA (CG-47), XO/Nav.
- Need to verify accuracy (and quality) of nav data in repository.
- Data vulnerability concern.

USS CALIFORNIA (CGN-36), Navigator
- Pictures of Ports, Piers, Passages, and Straits

- Description of Pier configuration

COMDESRON SIX, Ops/Plans
- "One-Stop-Shopping"
- Pictures of Navaids
- "Huge LAN w/ CD Jukebox"

USNS SAN JOSE (T-AFS-7), Navigator
- "Design (system/repository) so that merchants can voluntarily contribute feedback."

USS NICHOLAS (FFG-47), Asst. Navigator
- Include Suez Canal Transit info.

USS PAUL HAMILTON (DDG-60), CO
- Pier depths
- Pilot proficiency info., ex., years experience
- DDG: "Digital pubs save space"
- "Put pictures of navaids on the Web"

SUBMARINE SQUADRON TWO, Deputy Commander
- "Need adequate survey data for safe submerged operations in littoral shallow waters."
- "More local knowledge about direction and magnitude of current at various places along track."

DESTROYER SQUADRON SEVEN, CICO
- "Include standard 4W grids in Opareas to alleviate confusion."
- "DGPS...is of sufficient accuracy/quality to be used for harbor transits instead of visual fixes."
- Include Code of Federal Regs (CFR) Panama Canal Transit information.
<also: St. Lawrence Seaway and Locks, Kiel Canal/Locks, Suez Canal, etc.>
- Commands need to debrief Sea & Anchor details and capture the lessons learned.

USS GUAM (LPH-9), Asst. Navigator
- "USN should embrace the CAP'N program...current Instructions require us to operate in the Dark Ages!"

USS FITZGERALD (DDG-62), CICO
- Using Raytheon ECDISS

- Have NIMA conduct an annual NAVIGATION PLANNING Symposium to brief improvements in services and products.

USS JACKSONVILLE (SSN-699), Asst. Navigator
- Pictures of Navaids

SUBMARINE GROUP TWO, Ops. Officer
- Navigation Planning is far behind current technology!

USS SANTA FE (SSN-763), Nav/Ops
- "(Nav Info) System would need to be integrateable into SNAP-III LAN"
- Need up-to-date location info on Arabian Gulf and WESTPAC Oil Rig locations.
- Location info. On special purpose Buoys such as Hawaiian "Fish Aggregating Device" (FAD) Buoys.

USS PELELIU (LHA-5), Navigator/Asst. Navigator
- "Centrally locating multiple sources of Nav. Info. by a geographical database would be a great help!"
- Look at CJCS Instruction 6130.01 dtd 20May94 "CJCS Master Navigation Plan"
- Do away with traditional visual fixing; use GPS exclusive fixing!

USS POGY (SSN-647), Ops. /Nav.
- Traffic Density and Patterns

DESTROYER SQUADRON TWO, Chief of Staff
- Use TOPSCENE for Nav Planning

USS FRANK CABLE (AS-40), Nav/Ops
- Include Traffic Density data.

USS OHIO (SSBN-726), Navigator
- Include "Downloadable" Power Point Nav. Briefs.

AMPHIBIOUS SQUADRON SIX, Ops.
- Collect repository of (landing) beach hydrographic surveys.
- Mobile staffs would greatly benefit from digitized pubs and charts (Note: same reported by MCM's, SSN's, DDGs and FFGs)!

SIXTH FLEET, Asst. Fleet Scheduler
- Collect cost data with Port Visit Report per C6F prototype tool.

USS YORKTOWN (CG-48), CICO/Nav.
- "SMART SHIP" Plan: Only maintain one set of charts.

USS THE SULLIVANS (DDG-68), QM
- More pictures of Navaids (a picture is worth a thousand words).
- Pictures that show what the harbor looks like (NOAA Charts, do this with a few of those).
- Digital Charts - "new Coast Guard Buoy Tenders in Newport showed me the Digital Chart System that fed into the control stations - it was great!"
- Common pilot practices in different ports.

USS BELLEAU WOOD (LHA-3), Navigator
- Pictures of Harbor Approaches

USS PATRIOT (MCM-7), QM
- Recommended Port approaches
- Digital Nav Pubs, i.e., sailing directions and Pub 151
- "Put all Nav info. on a single, Worldwide network"
- Include EEZ, political boundaries, buffer zones, etc. on digital charts.

USS THORN (DD-988), Ops./Nav.
- Scalable, editable (digital) charts where operator can superimpose tracks, OPAREAS, etc.

USS JOHN F KENNEDY (CV-67), Navigator
- "Raytheon ECDIS disks were corrupted"
- Repository of feedback accessible through WWW
- All pubs accessible through WWW

USS FLETCHER (DD-992), Navigator
- Store PowerPoint Nav Briefs
- Need a "One-Stop Library"
- "Scaling feature" for digital charts

AMPHIBIOUS SQUADRON 11, CSO
- Repository of Beach Surveys
- Beach Imagery

USS THACH (FFG-43), Navigator
- Include merchant vessel feedback and lessons learned re: navigation.

SUBMARINE GROUP 7, ACOS/Ops.
- Make digital chart(s) "edgeless" so that you auto-shift to new chart.

USS MOUNT HOOD (AE-29), Navigator
- Include all (different) spellings for foreign ports.

AMPHIBIOUS SQUADRON FIVE, SAC
- E-mail feedback to a database.

USS GEORGE WASHINGTON (CVN-73), Navigator
- Have NIMA digitize OPAREA Charts and distribute via ECDIS
- Add to Nav library: Airfields (Bingo fields), Sub transit lanes, traffic separation schemes, oil rig locations.

Response Distribution-- All Responses
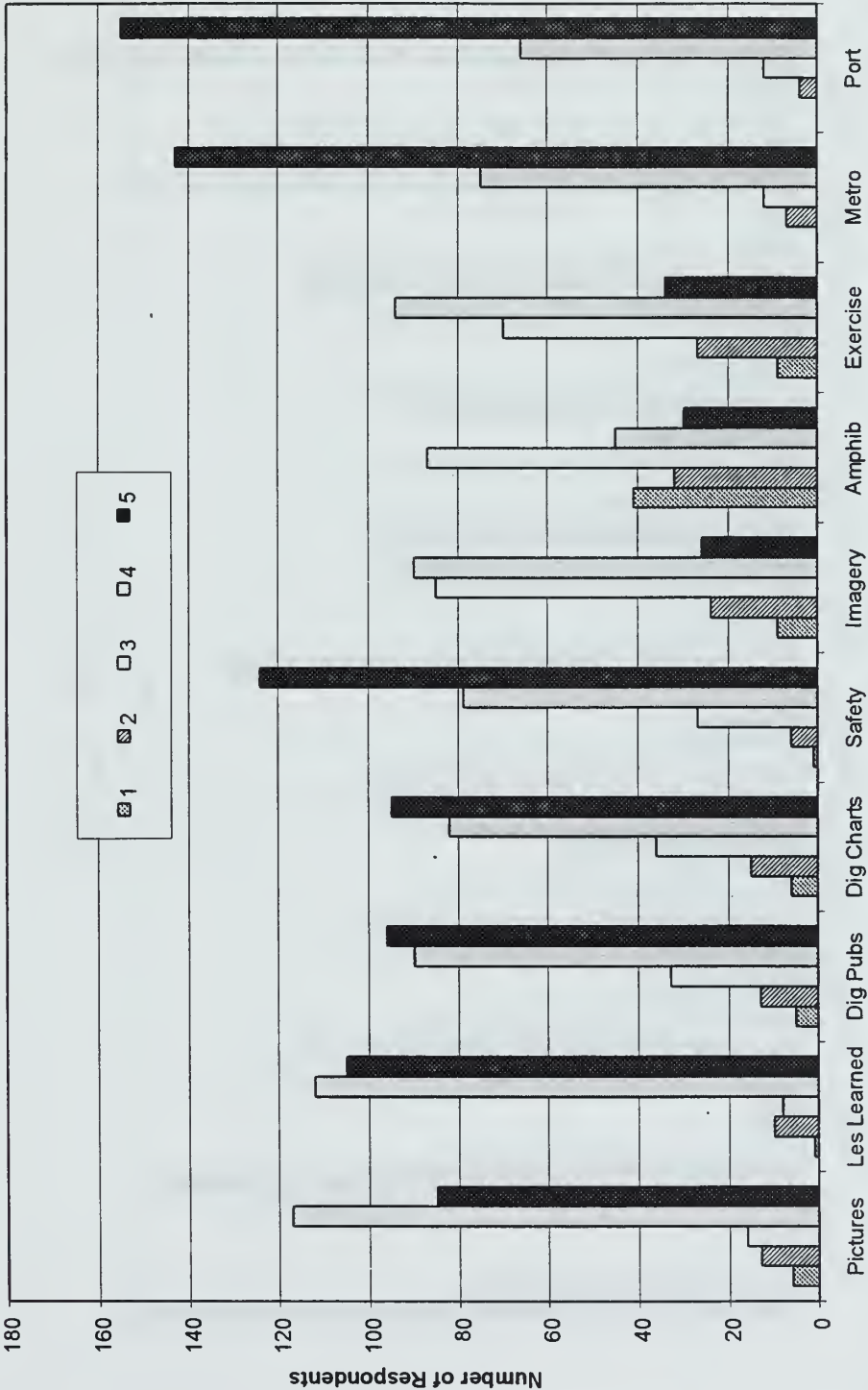
Graph F- 1

Response Distribution- One Survey per Command

Number of Respondents
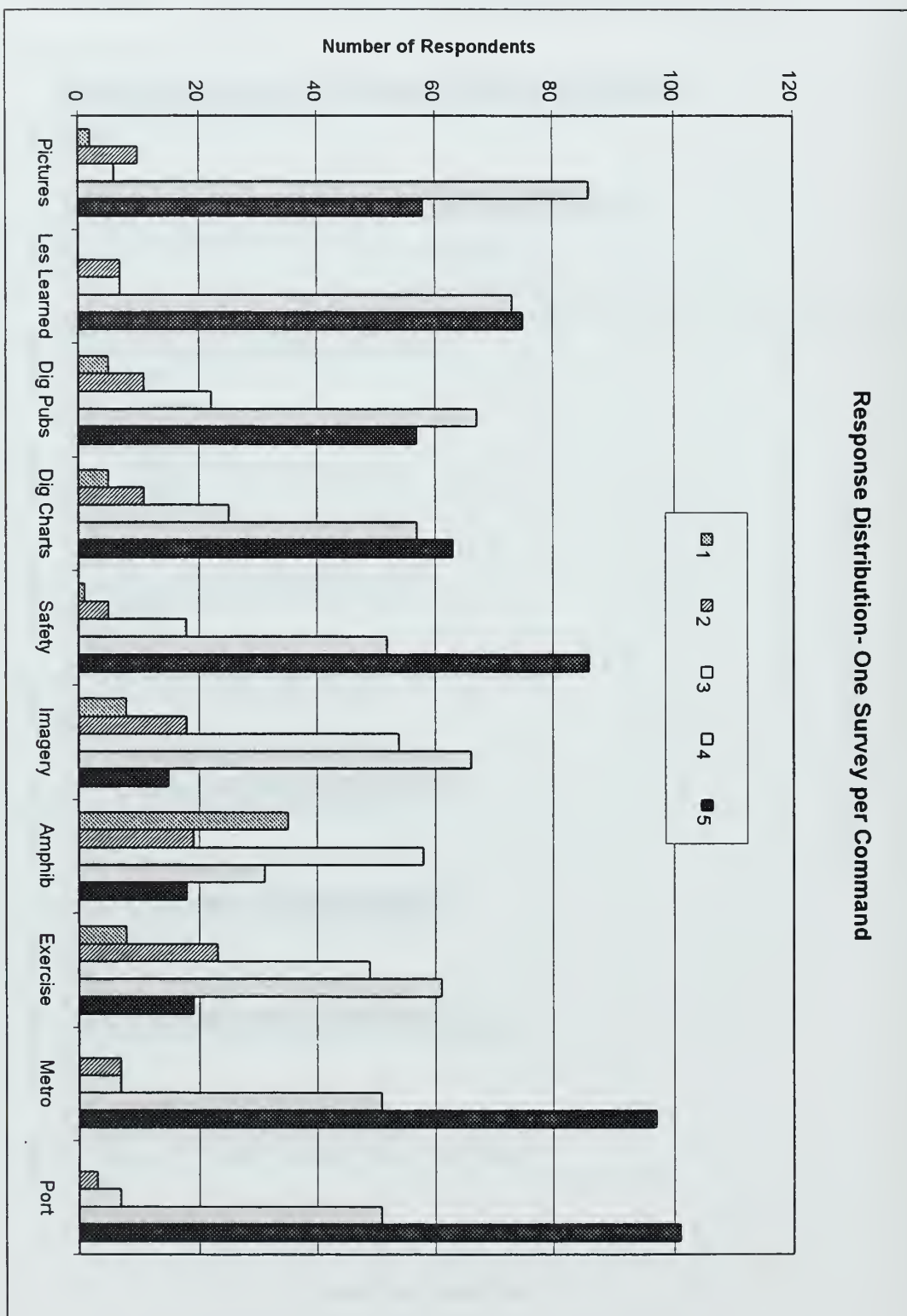
Graph F- 2

Response Distribution by Percent- All Respondents

Graph F- 3

109
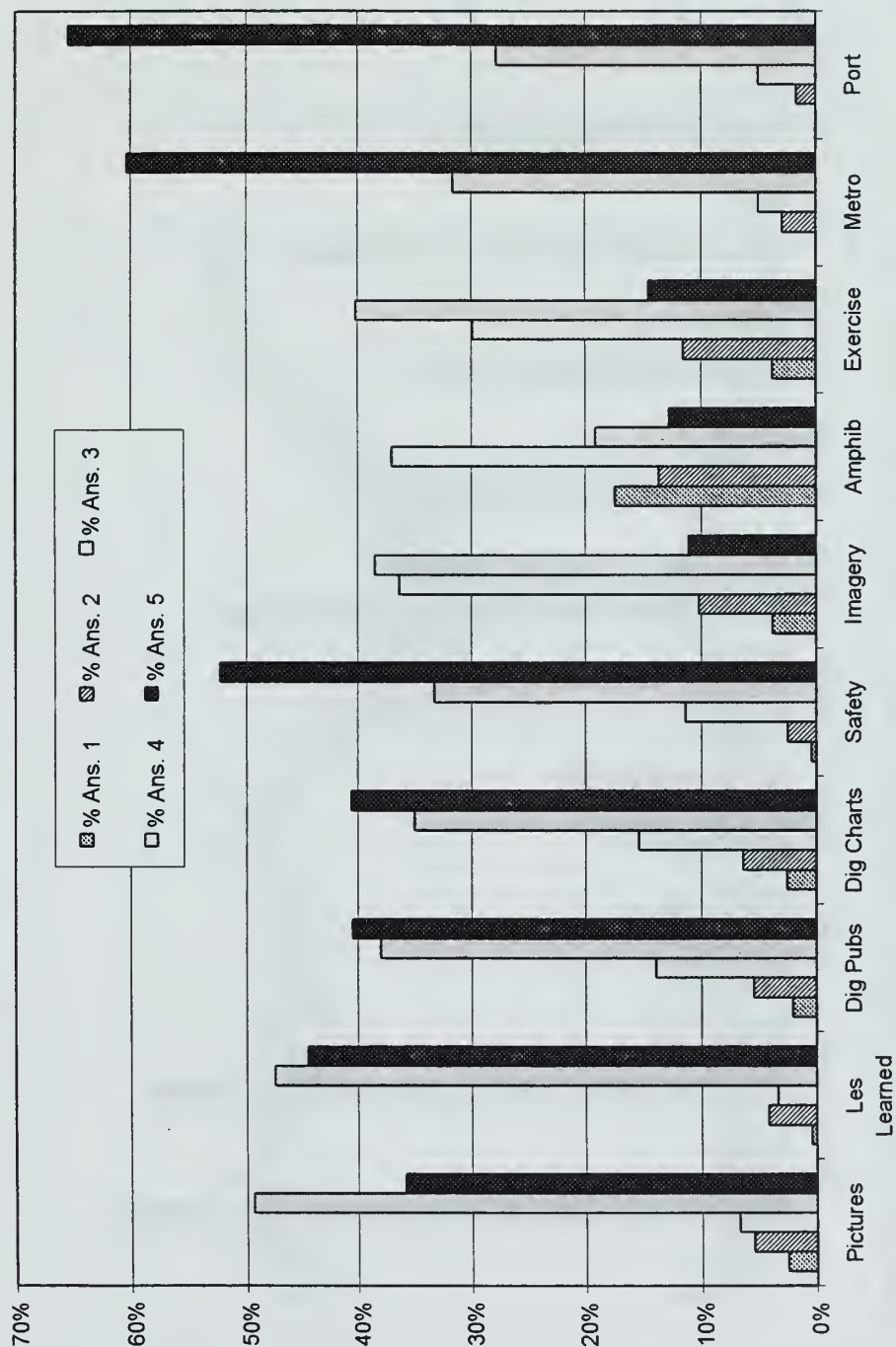
Graph F- 4

Response Distribution by Percent- One Survey per Command

110

Group Comparison

Graph F- 5

*Note: Standard Deviation is second color under group

ANAV Avg
sdev
NAV Avg
OPS Avg
Nav+ANAV Avg
QM Rating Avg
OS Rating Avg
>E-7 Avg
<=E-6 Avg
Enlisted Avg
JO's Avg
Officers Avg
>O-4 Avg
>0-5 Avg
Large Deck Avg
Small Boys Avg
Amphibs Avg
Subs Avg
Aux Avg
Staff Avg
PC/MCM/MHC Avg
Crudes Avg
Sub Related Avg
Ship Related Avg
< 12 Months Avg
12-36 Months Avg
>36 Months Avg

Pictures L-Learned Dig Pubs Dig Charts Safety Imagery Amphib Exer. Data Metro Port Data

6.00 5.00 4.00 3.00 2.00 1.00 0.00

111

Graph F- 6

Ship v Sub v Staff

Legend:
- Ship Avg
- Sub Avg
- Ship Mode
- Sub Mode
- Ship S. Dev
- Sub S. Dev
- Staff Avg
- Staff S. Dev
- Staff Mode

Categories (x-axis): Pictures, L-Learned, Dig Pubs, Dig Charts, Safety, Imagery, Amphib, Exer. Data, Metro, Port Data

Grouped By Command Type

Graph F- 7

113

Big Deck v Small Boy Graph

Graph F-8

Legend:
- Big Deck Avg
- Big Deck S.Dev
- Big Deck Mode
- Small Boy Avg
- Small Boy S. Dev
- Small Boy Mode

X-axis categories: Pictures, L-Learned, Dig Pubs, Dig Charts, Safety, Imagery, Amphib, Exer. Data, Metro, Port Data

Y-axis: 0.00, 1.00, 2.00, 3.00, 4.00, 5.00, 6.00

114
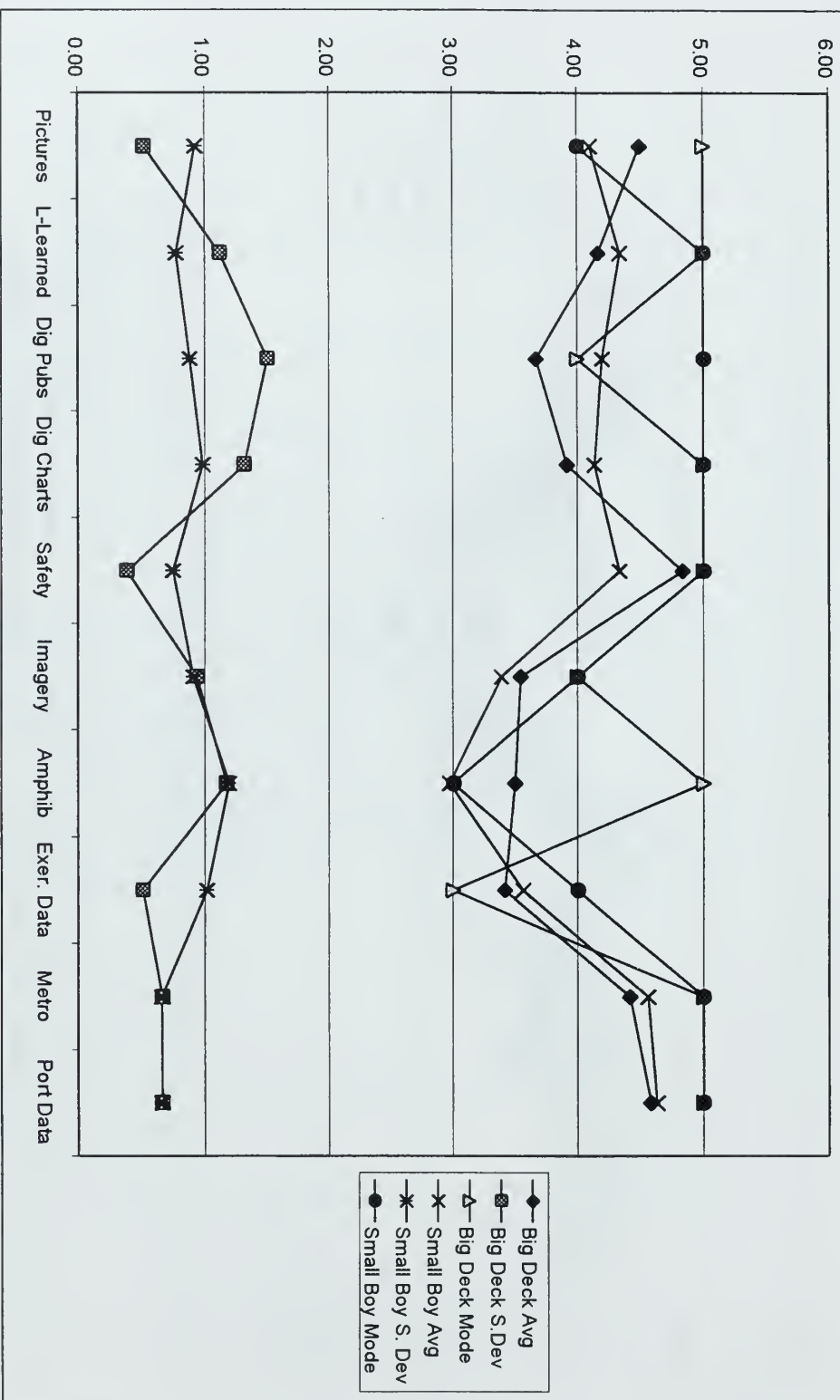
Operations Officers vs. Navigators

Graph F- 9

115
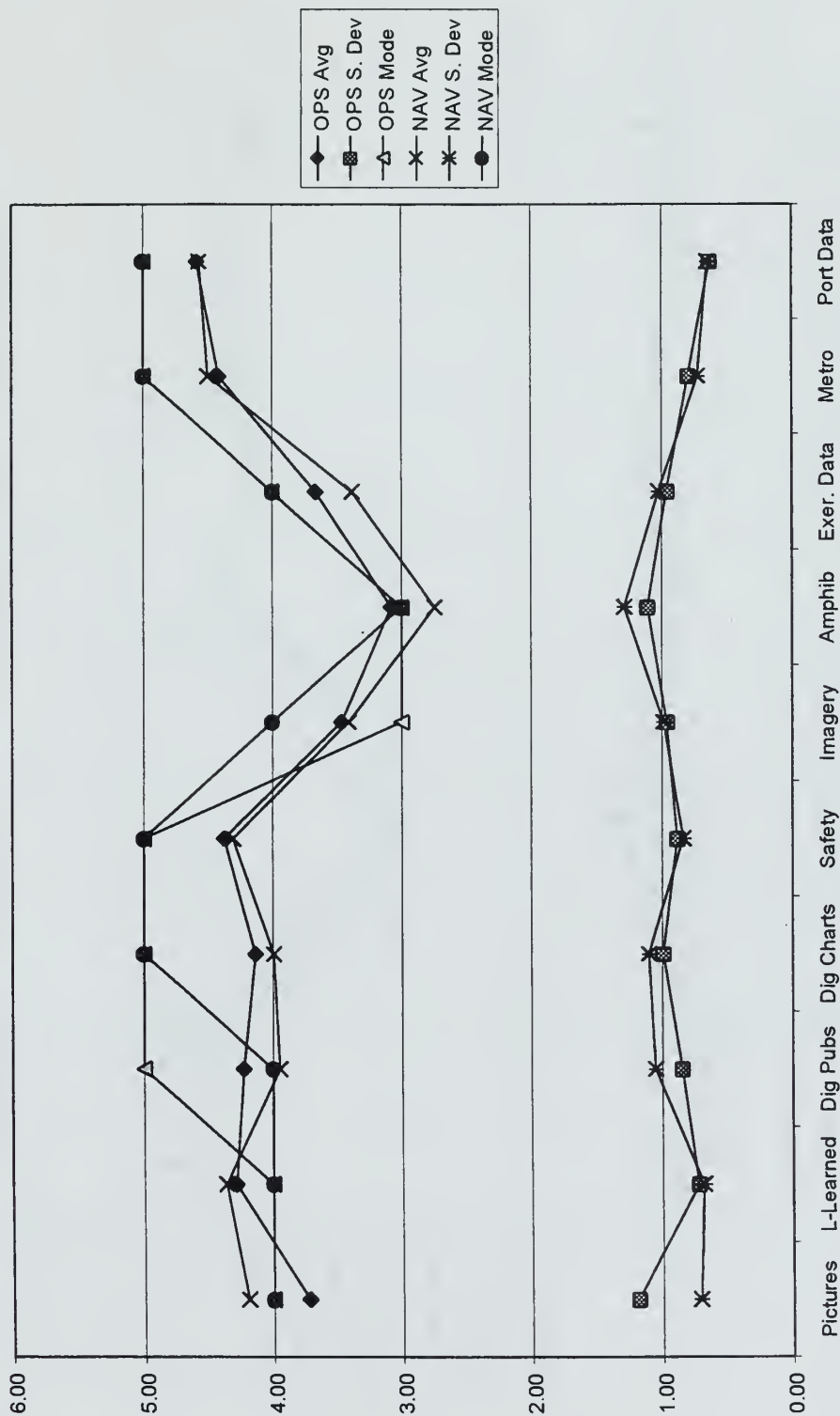
Time in Billet (Months)
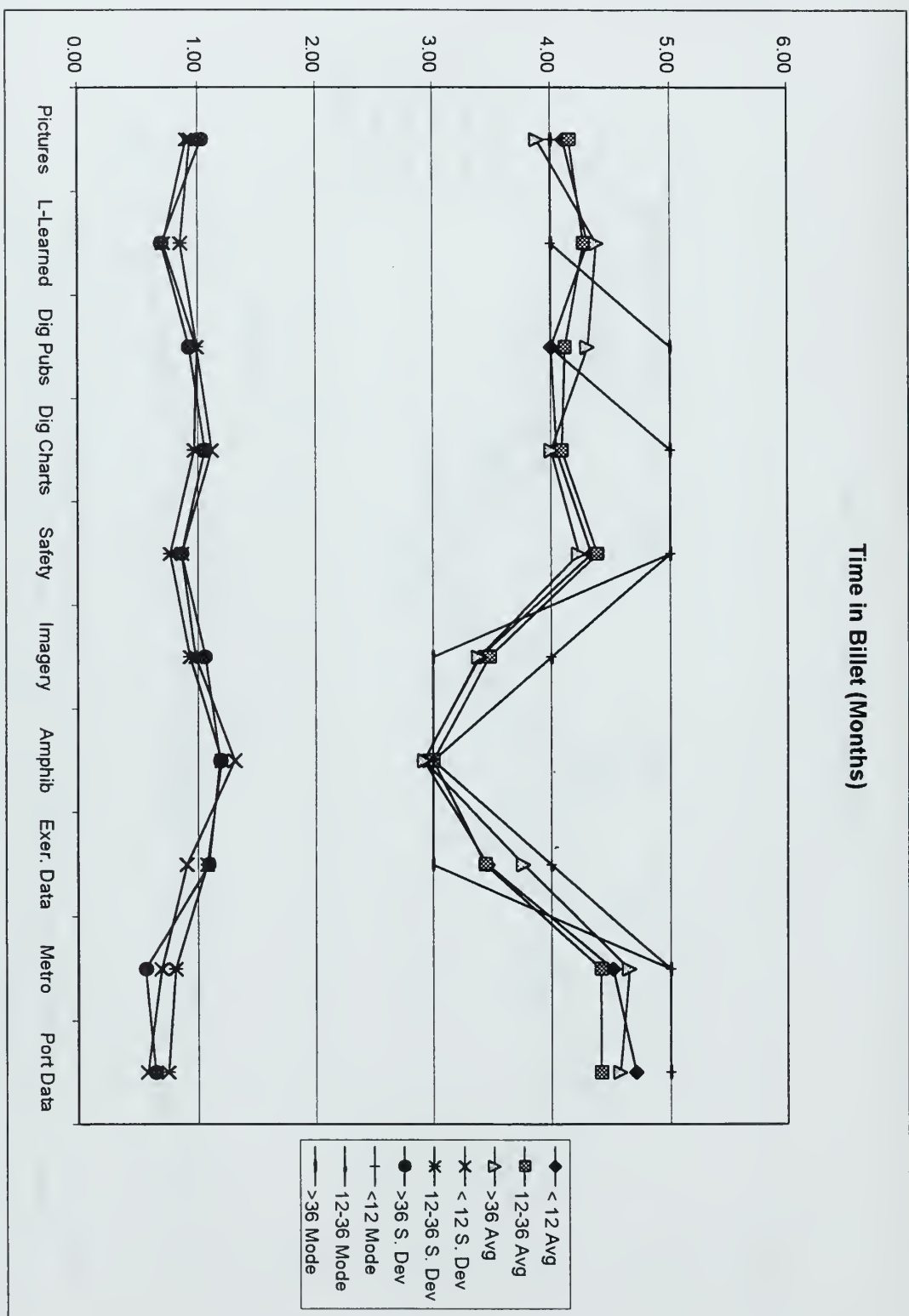
Graph F- 10
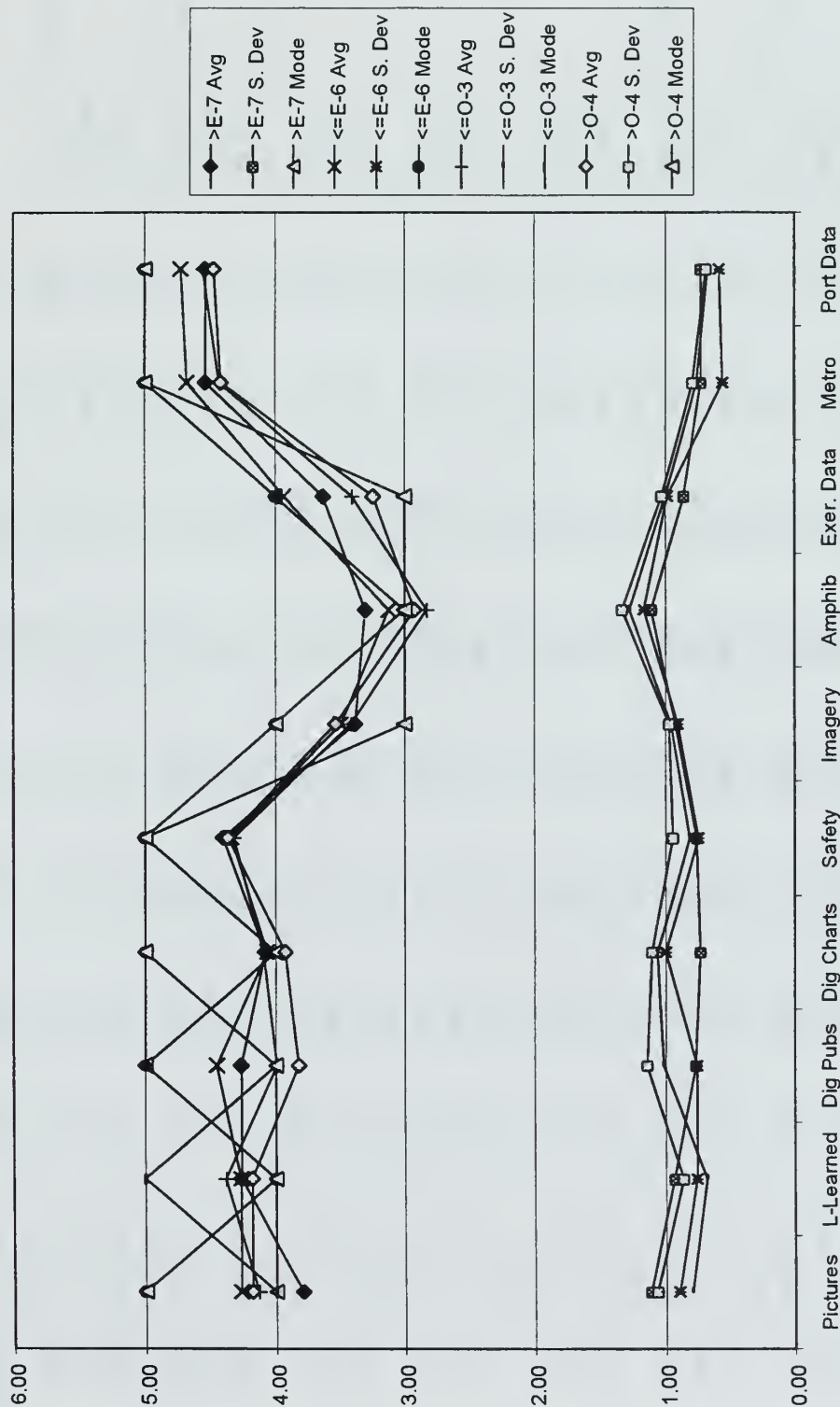
Legend:
- ◆ < 12 Avg
- ■ 12-36 Avg
- △ >36 Avg
- ✕ < 12 S. Dev
- ✳ 12-36 S. Dev
- ● >36 S. Dev
- ┼ <12 Mode
- │ 12-36 Mode
- │ >36 Mode

Categories (x-axis): Pictures, L-Learned, Dig Pubs, Dig Charts, Safety, Imagery, Amphib, Exer. Data, Metro, Port Data

Values (y-axis): 0.00, 1.00, 2.00, 3.00, 4.00, 5.00, 6.00

Graph F-11

		Time in Billet	Pictures	L-Learned	Digitized Pubs	Digitized Charts	Safety	Imagery	Amphib	Xercise Data	Metro	Port Data
All Respondent	Average	15.5	4.10	4.31	4.08	4.03	4.35	3.43	2.96	3.49	4.50	4.57
	Std Dev.	12.8	0.94	0.77	0.98	1.03	0.81	0.95	1.25	1.01	0.73	0.68
	Mode	12.0	4.00	4.00	5.00	5.00	5.00	4.00	3.00	4.00	5.00	5.00
1/Command	Average	14.5	4.15	4.32	3.97	3.99	4.34	3.38	2.85	3.36	4.46	4.54
	Std Dev.	11.7	0.86	0.76	1.03	1.06	0.85	0.97	1.28	1.03	0.78	0.67
	Mode	12.0	4.00	4.00	5.00	5.00	5.00	4.00	3.00	4.00	5.00	5.00
ANAV	Average	24.1	4.22	4.41	4.19	3.89	4.38	3.35	3.03	3.64	4.57	4.70
	Std Dev.	19.0	0.92	0.96	0.84	1.02	0.76	0.89	1.12	0.83	0.60	0.57
	Mode	12.0	4.00	5.00	4.00	5.00	5.00	4.00	3.00	3.00	5.00	5.00
NAV	Average	13.3	4.19	4.37	3.94	3.99	4.31	3.41	2.74	3.38	4.50	4.57
	Std Dev.	10.6	0.71	0.68	1.05	1.10	0.84	0.98	1.28	1.02	0.72	0.65
	Mode	6.0	4.00	4.00	4.00	4.00	5.00	3.00	3.00	3.00	5.00	5.00
OPS	Average	13.7	3.72	4.29	4.23	4.13	4.38	3.46	3.08	3.66	4.42	4.58
	Std Dev.	11.5	1.18	0.72	0.85	0.99	0.88	0.96	1.11	0.96	0.72	0.63
	Mode	12.0	4.00	4.00	4.00	5.00	5.00	4.00	3.00	4.00	5.00	5.00
Nav+ANAV	Average	14.9	4.22	4.40	4.00	3.97	4.32	3.42	2.82	3.44	4.52	4.60
	Std Dev.	12.5	0.73	0.68	1.02	1.09	0.82	0.96	1.27	1.00	0.69	0.63
	Mode	12.0	4.00	5.00	4.00	5.00	5.00	4.00	3.00	4.00	5.00	5.00
QM Rating	Average	22.0	4.26	4.19	4.36	4.07	4.29	3.44	3.16	3.79	4.60	4.67
	Std Dev.	16.5	0.85	0.93	0.81	0.97	0.79	0.91	1.11	0.94	0.67	0.60
	Mode	36.0	4.00	4.00	5.00	5.00	5.00	3.00	3.00	4.00	5.00	5.00

		Time in Billet	Pictures	L-Learned	Digitized Pubs	Digitized Charts	Safety	Imagery	Amphib	Xercise Data	Metro	Port Data
OS Rating	Average	22.9	3.50	4.45	4.41	4.00	4.50	3.36	3.14	3.73	4.59	4.50
	Std Dev.	16.0	1.30	0.51	0.67	0.89	0.60	1.05	1.25	1.03	0.59	0.80
	Mode	12.0	4.00	4.00	5.00	4.00	5.00	3.00	3.00	4.00	5.00	5.00
>E-7	Average	25.8	3.78	4.27	4.27	4.08	4.41	3.38	3.30	3.62	4.54	4.54
	Std Dev.	18.7	1.11	0.93	0.77	0.73	0.76	0.92	1.10	0.86	0.73	0.73
	Mode	12.0	4.00	4.00	5.00	4.00	5.00	3.00	3.00	4.00	5.00	5.00
<=E-6	Average	20.0	4.27	4.27	4.45	4.07	4.34	3.49	3.12	3.93	4.68	4.73
	Std Dev.	13.7	0.90	0.76	0.76	1.00	0.75	0.91	1.16	0.99	0.56	0.59
	Mode	36.0	5.00	4.00	5.00	5.00	5.00	4.00	3.00	4.00	5.00	5.00
Enlisted	Average	22.6	4.05	4.27	4.37	4.08	4.37	3.44	3.20	3.79	4.62	4.64
	Std Dev.	16.2	1.02	0.84	0.77	0.88	0.75	0.91	1.13	0.94	0.64	0.66
	Mode	12.0	4.00	4.00	5.00	4.00	5.00	3.00	3.00	4.00	5.00	5.00
JO's	Average	13.9	4.16	4.33	3.94	4.03	4.34	3.42	2.86	3.36	4.44	4.54
	Std Dev.	24.0	0.84	0.74	1.07	1.08	0.80	0.93	1.28	1.02	0.75	0.69
	Mode	12.0	4.00	4.00	4.00	5.00	5.00	4.00	3.00	4.00	5.00	5.00
Officers	Average	13.7	4.15	4.34	3.95	4.05	4.34	3.44	2.85	3.36	4.43	4.54
	Std Dev.	23.3	0.87	0.73	1.04	1.07	0.85	0.96	1.28	1.00	0.76	0.68
	Mode	12.0	4.00	4.00	4.00	5.00	5.00	4.00	3.00	4.00	5.00	5.00
>O-4	Average	15.7	4.18	4.18	3.82	3.92	4.37	3.53	2.92	3.24	4.42	4.47
	Std Dev.	11.2	1.06	0.87	1.14	1.10	0.94	0.97	1.32	1.02	0.79	0.69
	Mode	12.0	5.00	4.00	4.00	5.00	5.00	4.00	3.00	3.00	5.00	5.00
>0-5	Average	10.9	4.00	4.40	4.00	4.30	4.20	3.78	2.70	3.30	4.30	4.50
	Std Dev.	5.6	1.25	0.70	0.67	0.82	1.40	1.30	1.34	0.82	0.95	0.53
	Mode	12.0	5.00	5.00	4.00	5.00	5.00	5.00	2.00	4.00	5.00	4.00

		Time in Billet	Pictures	L-Learned	Digitized Pubs	Digitized Charts	Safety	Imagery	Amphib	Xercise Data	Metro	Port Data
Large Deck	Average	14.7	4.50	4.17	3.67	3.92	4.83	3.55	3.50	3.42	4.42	4.58
	Std Dev.	10.9	0.52	1.11	1.50	1.31	0.39	0.93	1.17	0.51	0.67	0.67
	Mode	19.0	5.00	5.00	4.00	5.00	5.00	4.00	5.00	3.00	5.00	5.00
Small Boys	Average	14.6	4.10	4.34	4.20	4.14	4.34	3.39	2.97	3.57	4.56	4.63
	Std Dev.	13.1	0.92	0.77	0.88	0.98	0.75	0.91	1.19	1.01	0.66	0.67
	Mode	6.0	5.00	5.00	4.00	5.00	5.00	4.00	5.00	3.00	5.00	5.00
Amphibs	Average	11.8	4.29	4.53	3.82	4.06	4.47	3.88	4.47	3.65	4.59	4.71
	Std Dev.	9.0	0.85	0.87	1.47	1.14	0.62	0.86	0.62	0.86	0.51	0.59
	Mode	6.0	4.00	5.00	5.00	5.00	5.00	4.00	5.00	3.00	5.00	5.00
Subs	Average	21.7	4.06	4.22	3.78	3.84	4.25	3.09	2.31	3.00	3.97	4.44
	Std Dev.	14.4	0.80	0.75	0.97	1.05	0.80	0.96	1.28	0.76	0.86	0.67
	Mode	29.0	4.00	4.00	4.00	4.00	5.00	4.00	1.00	3.00	5.00	5.00
Aux	Average	11.8	4.36	4.36	3.82	3.91	4.36	3.55	2.73	3.27	4.59	4.55
	Std Dev.	6.9	0.49	0.58	1.33	1.11	0.85	0.96	1.24	1.16	0.73	0.60
	Mode	14.0	4.00	4.00	5.00	5.00	5.00	3.00	1.00	3.00	5.00	5.00
Staff	Average	14.8	4.00	4.29	4.31	4.07	4.29	3.73	3.36	3.88	4.67	4.52
	Std Dev.	12.2	1.21	0.77	0.78	1.02	1.02	1.03	1.19	1.02	0.65	0.63
	Mode	12.0	5.00	4.00	4.00	5.00	5.00	4.00	3.00	4.00	5.00	5.00
PC/MCM/MHC	Average	13.2	3.82	4.14	4.39	4.39	4.43	3.29	3.11	3.61	4.50	4.54
	Std Dev.	5.3	1.06	0.76	0.88	0.83	0.63	0.85	1.10	0.99	0.64	0.69
	Mode	12.0	4.00	4.00	5.00	5.00	5.00	3.00	3.00	4.00	5.00	5.00

		Time in Billet	Pictures	L-Learned	Digitized Pubs	Digitized Charts	Safety	Imagery	Amphib	Xercise Data	Metro	Port Data
Crudes	Average	15.0	4.20	4.37	4.12	4.00	4.29	3.33	2.70	3.52	4.58	4.66
	Std Dev.	14.0	0.87	0.79	0.86	1.04	0.80	0.92	1.11	1.03	0.70	0.66
	Mode	8.0	4.00	5.00	4.00	5.00	5.00	3.00	3.00	4.00	5.00	5.00
Sub Related	Average	19.9	4.05	4.30	3.86	3.74	4.33	3.16	2.40	3.14	4.14	4.47
	Std Dev.	14.5	0.95	0.71	0.97	1.09	0.78	1.07	1.26	0.86	0.86	0.67
	Mode	12.0	4.00	4.00	4.00	4.00	5.00	3.00	3.00	3.00	4.00	5.00
Ship Related	Average	14.5	4.17	4.33	4.10	4.08	4.38	3.44	2.98	3.51	4.56	4.62
	Std Dev.	12.3	0.87	0.78	1.02	1.04	0.76	0.91	1.21	1.02	0.68	0.66
	Mode	6.0	4.00	5.00	5.00	5.00	5.00	4.00	3.00	4.00	5.00	5.00
< 12 Months	Average	5.7	4.10	4.31	4.00	4.04	4.34	3.40	2.92	3.46	4.52	4.71
	Std Dev.	2.8	0.91	0.71	0.99	1.12	0.86	0.98	1.31	0.91	0.69	0.58
	Mode	6.0	4.00	4.00	4.00	5.00	5.00	4.00	3.00	4.00	5.00	5.00
12-36 Months	Average	18.2	4.16	4.27	4.12	4.09	4.39	3.48	3.00	3.44	4.42	4.42
	Std Dev.	6.7	0.94	0.86	0.99	0.97	0.77	0.93	1.20	1.08	0.81	0.75
	Mode	12.0	4.00	4.00	5.00	5.00	5.00	4.00	3.00	4.00	5.00	5.00
>36 Months	Average	43.1	3.88	4.38	4.31	4.00	4.23	3.38	2.92	3.76	4.65	4.58
	Std Dev.	10.8	1.03	0.70	0.93	1.06	0.86	1.06	1.19	1.09	0.56	0.64
	Mode	36.0	4.00	4.00	5.00	5.00	5.00	3.00	3.00	3.00	5.00	5.00

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